APPLICATION UNDER UNITED STATES PATENT LAWS

Atty. Dkt. No. 061069-0306411

Invention: REAL IMAGE MODE FINDER OPTICAL SYSTEM

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This is a:

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☐ Regular Utility Application

☒ Divisional Application

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☐ PCT National Phase Application

☐ Design Application

☐ Reissue Application

☐ Plant Application

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Sub. Spec. filed ________________
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SPECIFICATION

REAL IMAGE MODE FINDER OPTICAL SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a real image mode finder optical system suitable for use in a lens shutter camera or an electronic still camera which is constructed so that a photographing optical system is independent of a finder optical system, and in particular, to a real image mode finder optical system which has a large angle of emergence and is best adapted for mounting to a compact camera.

2. Description of Related Art

In general, finders constructed to be independent of photographing optical systems, used in lens shutter cameras, are roughly divided into two classes: virtual image mode finders and real image mode finders.

The virtual image mode finder has the advantage that an image erecting optical system is not required, but has the disadvantage that since an entrance pupil is located at the same position as an observer's pupil, the diameter of a front lens must be increased or the area of a visual field is not defined. An Albada finder of this type allows the area of the visual field to be definitely set, but has the problem that a half mirror coating is applied to the surface of a lens and thus the transmittance of the lens is reduced or flare is increased.

In contrast to this, the real image mode finder is such that the position of the entrance pupil can be located on the object side, and hence the diameter of the front lens can be decreased. Moreover, by placing a field frame in the proximity of the imaging position of an objective lens, the area of the visual field can be defined without reducing the transmittance.

A conventional real image mode finder, however, dose not provide a sufficient angle of apparent visual field (hereinafter referred to as an angle of emergence). Specifically, an object to be observed can be viewed only in small size. Thus, when the object is a person, there is the problem that it is difficult to view the expression of the person. A finder with a relatively large angle of emergence is disclosed, for example, in each of Japanese Patent Preliminary Publication Nos. Hei 6-51201 and Hei 11-242167. However, even such a finder does not provide a sufficiently large angle of emergence.

A so-called telescope has a large angle of emergence. However, the telescope, which has a high magnification, namely a small angle of visual field, cannot be applied to a finder constructed to be independent of the photographing optical system, used in a common lens shutter camera which has a wide angle of view.

SUMMARY OF THE INVENTION

It is, therefore, an object of the present invention to provide a real image mode finder optical system in which the angle of emergence can be increased and compactness can be attained.

In order to achieve this object, the real image mode finder optical system according to the present invention is constructed to be independent of the photographing optical system and has, in order from the object side, an objective optical system with a positive refracting power, a field frame located in the proximity of the imaging position of the objective optical system, and an eyepiece optical system with a positive refracting power. The real image mode finder optical system includes an image erecting means, and the focal length of the objective optical system can be made shorter than that of the eyepiece optical system. In this case, the real image mode finder optical system satisfies the following condition:

$$0.52 < mh / fe < 1 \quad (1)$$

where mh is the maximum width of the field frame and fe is the focal length of the eyepiece optical system.

The real image mode finder optical system according to the present invention is constructed to be independent of the photographing optical system and has, in order from the object side, an objective optical system with a positive refracting power, a field frame located in the proximity of the imaging position of the objective optical system, and an eyepiece optical system with a positive refracting power. The real image mode finder optical system includes an image erecting means, the objective optical system includes three of reflecting surfaces of the image erecting means, and the eyepiece optical system includes one of reflecting surfaces of the image erecting means so that an image is erected through four reflecting surfaces comprised of three reflecting surfaces of the objective optical system and one reflecting surface of the eyepiece optical system. The focal length of the objective optical system is variable, and when the magnification of the finder optical system is changed, at least two lens units are moved along different paths. The focal length of the objective optical system at the wide-angle position thereof is shorter than that of the eyepiece optical system. In this case, the real image mode finder optical system satisfies Condition (1).

The real image mode finder optical system according to the present invention is constructed to be independent of the photographing optical system and has, in order from the object side, an objective optical system with a positive refracting power, a field frame located in the proximity of the imaging position of the objective optical system, and an eyepiece optical system with a positive refracting power. The real image mode finder optical system includes an image erecting means, the objective optical system includes three of reflecting surfaces of the image erecting means, and the eyepiece optical system includes one of reflecting surfaces of the image erecting means so that an image is erected through four reflecting surfaces comprised of three

reflecting surfaces of the objective optical system and one reflecting surface of the eyepiece optical system. The focal length of the objective optical system is variable, and when the magnification of the finder optical system is changed, at least two lens units are moved along different paths. The focal length of the objective optical system at the wide-angle position thereof is shorter than that of the eyepiece optical system. The image erecting means including the three reflecting surfaces is constructed with two prisms so that each of the prisms has at least one reflecting surface and one of the entrance surface and the exit surface of each prism is configured as a curved surface with finite curvature.

The real image mode finder optical system according to the present invention is constructed to be independent of the photographing optical system and has, in order from the object side, an objective optical system with a positive refracting power, a field frame located in the proximity of the imaging position of the objective optical system, and an eyepiece optical system with a positive refracting power. The objective optical system has an image erecting means including four reflecting surfaces. The focal length of the objective optical system is variable, and when the magnification of the finder optical system is changed, at least two lens units are moved along different paths. The focal length of the objective optical system at the wide-angle position thereof is shorter than that of the eyepiece optical system. In this case, the real image mode finder optical system satisfies Condition (1).

The real image mode finder optical system according to the present invention is constructed to be independent of the photographing optical system and has, in order from the object side, an objective optical system with a positive refracting power, a field frame located in the proximity of the imaging position of the objective optical system, and an eyepiece optical system with a positive refracting power. The objective optical system has an image erecting means including four reflecting surfaces.

The focal length of the objective optical system is variable, and when the magnification of the finder optical system is changed, at least two lens units are moved along different paths. The focal length of the objective optical system at the wide-angle position thereof is shorter than that of the eyepiece optical system.

This and other objects as well as the features and advantages of the present invention will become apparent from the following detailed description of the preferred embodiments when taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a perspective view showing of a first embodiment of the real image mode finder optical system according to the present invention;

Fig. 2 is a plan view of the real image mode finder optical system of Fig. 1;

Fig. 3 is a side view of the real image mode finder optical system of Fig. 1;

Fig. 4 is an explanatory view of a field frame used in the real image mode finder optical system of the first embodiment;

Figs. 5A, 5B, and 5C are sectional views showing arrangements, developed along the optical axis, at wide-angle, middle, and telephoto positions, respectively, of the real image mode finder optical system in the first embodiment;

Figs. 6A, 6B, 6C, and 6D are diagrams showing aberration characteristics at the wide-angle position of the real image mode finder optical system in the first embodiment;

Figs. 7A, 7B, 7C, and 7D are diagrams showing aberration characteristics at the middle position of the real image mode finder optical system in the first embodiment;

Figs. 8A, 8B, 8C, and 8D are diagrams showing aberration characteristics at the telephoto position of the real image mode finder optical system in the first embodiment;

Figs. 9A, 9B, and 9C are sectional views showing arrangements, developed along

the optical axis, at wide-angle, middle, and telephoto positions, respectively, of the real image mode finder optical system in a second embodiment;

Figs. 10A, 10B, 10C, and 10D are diagrams showing aberration characteristics at the wide-angle position of the real image mode finder optical system in the second embodiment;

Figs. 11A, 11B, 11C, and 11D are diagrams showing aberration characteristics at the middle position of the real image mode finder optical system in the second embodiment;

Figs. 12A, 12B, 12C, and 12D are diagrams showing aberration characteristics at the telephoto position of the real image mode finder optical system in the second embodiment;

Figs. 13A, 13B, and 13C are sectional views showing arrangements, developed along the optical axis, at wide-angle, middle, and telephoto positions, respectively, of the real image mode finder optical system in a third embodiment;

Figs. 14A, 14B, 14C, and 14D are diagrams showing aberration characteristics at the wide-angle position of the real image mode finder optical system in the third embodiment;

Figs. 15A, 15B, 15C, and 15D are diagrams showing aberration characteristics at the middle position of the real image mode finder optical system in the third embodiment;

Figs. 16A, 16B, 16C, and 16D are diagrams showing aberration characteristics at the telephoto position of the real image mode finder optical system in the third embodiment;

Figs. 17A, 17B, and 17C are sectional views showing arrangements, developed along the optical axis, at wide-angle, middle, and telephoto positions, respectively, of the real image mode finder optical system in a fourth embodiment;

Figs. 18A, 18B, 18C, and 18D are diagrams showing aberration characteristics at the wide-angle position of the real image mode finder optical system in the fourth embodiment;

Figs. 19A, 19B, 19C, and 19D are diagrams showing aberration characteristics at the middle position of the real image mode finder optical system in the fourth embodiment;

Figs. 20A, 20B, 20C, and 20D are diagrams showing aberration characteristics at the telephoto position of the real image mode finder optical system in the fourth embodiment;

Figs. 21A, 21B, and 21C are sectional views showing arrangements, developed along the optical axis, at wide-angle, middle, and telephoto positions, respectively, of the real image mode finder optical system in a fifth embodiment;

Figs. 22A, 22B, 22C, and 22D are diagrams showing aberration characteristics at the wide-angle position of the real image mode finder optical system in the fifth embodiment;

Figs. 23A, 23B, 23C, and 23D are diagrams showing aberration characteristics at the middle position of the real image mode finder optical system in the fifth embodiment;

Figs. 24A, 24B, 24C, and 24D are diagrams showing aberration characteristics at the telephoto position of the real image mode finder optical system in the fifth embodiment;

Figs. 25A, 25B, 25C, and 25D are sectional views showing arrangements, developed along the optical axis, at wide-angle, middle, and telephoto positions and with respect to an eyepiece optical system, respectively, of the real image mode finder optical system in a sixth embodiment;

Figs. 26A, 26B, 26C, and 26D are diagrams showing aberration characteristics at

the wide-angle position of the real image mode finder optical system in the sixth embodiment;

Figs. 27A, 27B, 27C, and 27D are diagrams showing aberration characteristics at the middle position of the real image mode finder optical system in the sixth embodiment;

Figs. 28A, 28B, 28C, and 28D are diagrams showing aberration characteristics at the telephoto position of the real image mode finder optical system in the sixth embodiment;

Figs. 29A, 29B, 29C, and 29D are diagrams showing aberration characteristics of the eyepiece optical system of the real image mode finder optical system in the sixth embodiment;

Figs. 30A, 30B, 30C, and 30D are sectional views showing arrangements, developed along the optical axis, at wide-angle, middle, and telephoto positions and with respect to an eyepiece optical system, respectively, of the real image mode finder optical system in a seventh embodiment;

Figs. 31A, 31B, 31C, and 31D are diagrams showing aberration characteristics at the wide-angle position of the real image mode finder optical system in the seventh embodiment;

Figs. 32A, 32B, 32C, and 32D are diagrams showing aberration characteristics at the middle position of the real image mode finder optical system in the seventh embodiment;

Figs. 33A, 33B, 33C, and 33D are diagrams showing aberration characteristics at the telephoto position of the real image mode finder optical system in the seventh embodiment;

Figs. 34A, 34B, 34C, and 34D are diagrams showing aberration characteristics of the eyepiece optical system of the real image mode finder optical system in the seventh

embodiment;

Figs. 35A, 35B, 35C, and 35D are sectional views showing arrangements, developed along the optical axis, at wide-angle, middle, and telephoto positions and with respect to an eyepiece optical system, respectively, of the real image mode finder optical system in an eighth embodiment;

Figs. 36A, 36B, 36C, and 36D are diagrams showing aberration characteristics at the wide-angle position of the real image mode finder optical system in the eighth embodiment;

Figs. 37A, 37B, 37C, and 37D are diagrams showing aberration characteristics at the middle position of the real image mode finder optical system in the eighth embodiment;

Figs. 38A, 38B, 38C, and 38D are diagrams showing aberration characteristics at the telephoto position of the real image mode finder optical system in the eighth embodiment;

Figs. 39A, 39B, 39C, and 39D are diagrams showing aberration characteristics of the eyepiece optical system of the real image mode finder optical system in the eighth embodiment;

Figs. 40A, 40B, 40C, and 40D are sectional views showing arrangements, developed along the optical axis, at wide-angle, middle, and telephoto positions and with respect to an eyepiece optical system, respectively, of the real image mode finder optical system in a ninth embodiment;

Figs. 41A, 41B, 41C, and 41D are diagrams showing aberration characteristics at the wide-angle position of the real image mode finder optical system in the ninth embodiment;

Figs. 42A, 42B, 42C, and 42D are diagrams showing aberration characteristics at the middle position of the real image mode finder optical system in the ninth embodi-

ment;

Figs. 43A, 43B, 43C, and 43D are diagrams showing aberration characteristics at the telephoto position of the real image mode finder optical system in the sixth embodiment;

Figs. 44A, 44B, 44C, and 44D are diagrams showing aberration characteristics of the eyepiece optical system of the real image mode finder optical system in the ninth embodiment;

Figs. 45A, 45B, 45C, and 45D are sectional views showing arrangements, developed along the optical axis, at wide-angle, middle, and telephoto positions and with respect to an eyepiece optical system, respectively, of the real image mode finder optical system in a tenth embodiment;

Figs. 46A, 46B, 46C, and 46D are diagrams showing aberration characteristics at the wide-angle position of the real image mode finder optical system in the tenth embodiment;

Figs. 47A, 47B, 47C, and 47D are diagrams showing aberration characteristics at the middle position of the real image mode finder optical system in the tenth embodiment;

Figs. 48A, 48B, 48C, and 48D are diagrams showing aberration characteristics at the telephoto position of the real image mode finder optical system in the tenth embodiment;

Figs. 49A, 49B, 49C, and 49D are diagrams showing aberration characteristics of the eyepiece optical system of the real image mode finder optical system in the tenth embodiment;

Figs. 50A, 50B, 50C, and 50D are sectional views showing arrangements, developed along the optical axis, at wide-angle, middle, and telephoto positions and with respect to an eyepiece optical system, respectively, of the real image mode finder opti-

cal system in an eleventh embodiment;

Figs. 51A, 51B, 51C, and 51D are diagrams showing aberration characteristics at the wide-angle position of the real image mode finder optical system in the eleventh embodiment;

Figs. 52A, 52B, 52C, and 52D are diagrams showing aberration characteristics at the middle position of the real image mode finder optical system in the eleventh embodiment;

Figs. 53A, 53B, 53C, and 53D are diagrams showing aberration characteristics at the telephoto position of the real image mode finder optical system in the eleventh embodiment;

Figs. 54A, 54B, 54C, and 54D are diagrams showing aberration characteristics of the eyepiece optical system of the real image mode finder optical system in the eleventh embodiment;

Figs. 55A, 55B, and 55C are sectional views showing arrangements, developed along the optical axis, at wide-angle, middle, and telephoto positions, respectively, of the real image mode finder optical system in a twelfth embodiment;

Figs. 56A, 56B, and 56C are sectional views showing arrangements, developed along the optical axis, at wide-angle, middle, and telephoto positions, respectively, of the real image mode finder optical system in a thirteenth embodiment;

Figs. 57A, 57B, and 57C are sectional views showing arrangements, developed along the optical axis, at wide-angle, middle, and telephoto positions, respectively, of the real image mode finder optical system in a fourteenth embodiment;

Figs. 58A, 58B, and 58C are sectional views showing arrangements, developed along the optical axis, at wide-angle, middle, and telephoto positions, respectively, of the real image mode finder optical system in a fifteenth embodiment;

Figs. 59A, 59B, and 59C are sectional views showing arrangements, developed

along the optical axis, at wide-angle, middle, and telephoto positions, respectively, of the real image mode finder optical system in a sixteenth embodiment;

Figs. 60A, 60B, and 60C are sectional views showing arrangements, developed along the optical axis, at wide-angle, middle, and telephoto positions, respectively, of the real image mode finder optical system in a seventeenth embodiment;

Figs. 61A, 61B, and 61C are sectional views showing arrangements, developed along the optical axis, at wide-angle, middle, and telephoto positions, respectively, of the real image mode finder optical system in an eighteenth embodiment;

Figs. 62A, 62B, and 62C are sectional views showing arrangements, developed along the optical axis, at wide-angle, middle, and telephoto positions, respectively, of the real image mode finder optical system in a nineteenth embodiment;

Figs. 63A, 63B, and 63C are sectional views showing arrangements, developed along the optical axis, at wide-angle, middle, and telephoto positions, respectively, of the real image mode finder optical system in a twentieth embodiment;

Figs. 64A, 64B, and 64C are sectional views showing arrangements, developed along the optical axis, at wide-angle, middle, and telephoto positions, respectively, of the real image mode finder optical system in a twenty-first embodiment;

Fig. 65 is a plan view of the real image mode finder optical system in the twenty-first embodiment;

Fig. 66 is a side view of the real image mode finder optical system of Fig. 65;

Fig 67 is a rear view of the real image mode finder optical system of Fig. 65;

Figs. 68A, 68B, and 68C are sectional views showing arrangements, developed along the optical axis, at wide-angle, middle, and telephoto positions, respectively, of the real image mode finder optical system in a twenty-second embodiment;

Figs. 69A, 69B, and 69C are sectional views showing arrangements, developed along the optical axis, at wide-angle, middle, and telephoto positions, respectively, of

the real image mode finder optical system in a twenty-third embodiment;

Figs. 70A, 70B, and 70C are sectional views showing arrangements, developed along the optical axis, at wide-angle, middle, and telephoto positions, respectively, of the real image mode finder optical system in a twenty-fourth embodiment;

Fig. 71 is a front perspective view showing the appearance of an electronic camera in an embodiment of a photographing apparatus using the real image mode finder optical system of the present invention:

Fig. 72 is a rear perspective view of the electronic camera of Fig. 71;

Fig. 73 is a sectional view showing the structure of the electronic camera of Fig. 71; and

Figs. 74A, 74B, and 74C are sectional views showing arrangements, developed along the optical axis, at wide-angle, middle, and telephoto positions, respectively, of a photographing zoom lens used in a compact camera for a 35 mm film (the maximum image height of 21.6 mm).

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

According to the present invention, when the objective optical system is designed to have the focal length shorter than that of the eyepiece optical system, the magnification of the real image mode finer optical system can be reduced to 1× or less, and as a result, the angle of visual field can be increased.

Condition (1) in the present invention is related to the angle of emergence. In order to increase the angle of emergence, it is only necessary to increase the size of an image obtained by the objective optical system, that is, the size of the field frame, or to reduce the focal length of the eyepiece optical system.

Below the lower limit of Condition (1), the image can be seen only in small size. On the other hand, beyond the upper limit of Condition (1), it becomes difficult to grasp the entire area of the visual field, for example, to quickly determine a picture

composition.

By constructing the finder optical system to be independent of the photographing optical system, the value of a maximum width mh of the field frame can be set, irrespective of the size of an imaging plane. This is particularly advantageous for compact design of the eyepiece optical system and for the placement of an image erecting means.

It is favorable that the real image mode finder optical system of the present invention is constructed so that the focal length of the objective optical system is variable, and when the magnification of the finder is changed, at least two lens units are moved along different paths.

When the objective optical system is constructed so that its focal length can be changed, a constant angle of emergence can be obtained, without changing the size of the field frame, even when the magnification is changed.

When the angle of emergence is increased, the phenomenon of a so-called diopter shift will occur if the back focal position is shifted. However, when at least two lens units are moved along different paths to change the magnification, the back focal position of the objective optical system can be kept to be nearly constant.

It is desirable that the real image mode finder optical system of the present invention satisfies the following condition:

$$12.0 \text{ mm} < fe < 18.0 \text{ mm} \qquad (2)$$

Condition (2) is provided for the purpose of ensuring a space for placing the image erecting means and compactness of the whole of the real image mode finder optical system in a state where Condition (1) is satisfied.

If the lower limit of Condition (2) is passed, a distance on the optical axis between the front principal point of the eyepiece optical system and the field frame will be reduced and at the same time, the finder magnification will be as low as 1× or less.

Therefore, a distance on the optical axis between the rear principal point of the objective optical system and the field frame is also reduced, and it becomes difficult to place the image erecting means, which is not favorable.

On the other hand, beyond the upper limit of Condition (2), the maximum width mh of the field frame must be enlarged to increase the angle of emergence. In this case, the objective optical system becomes bulky and the balance between the angle of emergence and the size of the real image mode finder ceases to be kept, which is unfavorable.

It is more desirable that the real image mode finder optical system satisfies the following condition:

$$13.5\text{ mm} < fe < 16.5\text{ mm} \qquad (3)$$

It is favorable that the real image mode finder optical system is constructed so that the objective optical system includes three reflecting surfaces of the image erecting means and the eyepiece optical system includes one reflecting surface of the image erecting means to erect an image with four reflecting surfaces comprised of the three reflecting surfaces of the objective optical system and the one reflecting surface of the eyepiece optical system.

At least four reflecting surfaces are required for the image erecting means, and thus if the image erecting means is constructed with four reflecting surfaces, space efficiency can be improved. When three of four reflecting surfaces constituting the image erecting means are placed in the objective optical system, the burden of a space for placing the image erecting means to the eyepiece optical system is lessened, and the number of optical elements constituting the eyepiece optical system can be reduced. Thus, according to the present invention, a real image mode finder optical system with a large angle of emergence can be constructed in a state where the arrangement of the eyepiece optical system is simplified.

It is favorable that the real image mode finder optical system of the present invention is constructed so that the objective optical system has the image erecting means including four reflecting surfaces to erect the image with the four reflecting surfaces of the objective optical system.

In this case, at least four reflecting surfaces are required for the image erecting means, and thus if the image erecting means is constructed with four reflecting surfaces, space efficiency can be improved. When the image erecting means is placed in the objective optical system, the burden of a space for placing the image erecting means to the eyepiece optical system is eliminated, and the eyepiece optical system can be constructed with a small number of lenses. Consequently, the focal length of the eyepiece optical system can be completely reduced, and aberration characteristics are easily improved. Thus, according to the present invention, a real image mode finder optical system with a large angle of emergence can be constructed in a state where the arrangement of the eyepiece optical system is simplified.

As mentioned above, when the objective optical system is designed to have the focal length shorter than that of the eyepiece optical system, the magnification of the real image mode finer optical system can be reduced to 1× or less, and as a result, the angle of visual field can be increased. Condition (1) in the present invention is related to the angle of emergence.

Below the lower limit of Condition (1), the image can be seen only in small size. On the other hand, beyond the upper limit of Condition (1), it becomes difficult to grasp the entire area of the visual field, for example, to quickly determine a picture composition.

When the objective optical system is constructed so that its focal length can be changed, a constant angle of emergence can be obtained, without changing the size of the field frame, even when the magnification is changed.

When the angle of emergence is increased, the phenomenon of a so-called diopter shift will occur if the back focal position is shifted. However, when at least two lens units are moved along different paths to change the magnification, the back focal position of the objective optical system can be kept to be nearly constant.

At least four reflecting surfaces are required for the image erecting means, and thus if the image erecting means is constructed with four reflecting surfaces, space efficiency can be improved. When three of four reflecting surfaces constituting the image erecting means are placed in the objective optical system, the burden of a space for placing the image erecting means to the eyepiece optical system is lessened, and the number of optical elements constituting the eyepiece optical system can be reduced. Thus, according to the present invention, the focal length of the eyepiece optical system can be completely reduced, and aberration characteristics are easily improved. Also, the objective optical system has a large number of lenses because of the magnification change, and hence can be designed to ensure a space for incorporating three reflecting surfaces in the objective optical system. Consequently, a real image mode finder optical system which has a large angle of emergence and is compact in design can be constructed in a state where the arrangement of the eyepiece optical system is simplified.

It is desirable that the real image mode finder optical system of the present invention is constructed so that the objective optical system comprises, in order from the object side, a first unit with a negative power, fixed or moved when the magnification is changed; a second unit with a positive power, moved when the magnification is changed; a third unit with a negative power, moved when the magnification is changed; and a fourth unit with a positive power, fixed when the magnification is change and including three reflecting surfaces.

According to the present invention, it becomes easy to achieve compactness of

the whole of the real image mode finder optical system and to obtain favorable aberration and a large angle of emergence.

It is desirable that the real image mode finder optical system of the present invention is constructed so that the fourth unit includes at least one prism having at least one reflecting surface, and one of the entrance surface and the exit surface of the prism is configured as a curved surface with finite curvature.

According to the present invention, a lens function, such as a contribution to the focal length or correction for aberration, as the fourth unit of the objective optical system and an image erecting function can be exerted in the same space.

Furthermore, it is desirable that the real image mode finder optical system of the present invention is constructed so that one of the reflecting surfaces of the prism is configured as a totally reflecting surface.

If total reflection is utilized as far as possible with respect to the reflecting surfaces of the prism, the transmittance of the entire finder can be improved accordingly.

In the real image mode finder optical system, it is desirable that each of the first unit, the second unit, and the third unit is constructed with a single lens.

According to the present invention, it becomes easy to achieve compactness of the whole of the real image mode finder optical system.

Moreover, it is desirable that the real image mode finder optical system of the present invention is constructed so that the eyepiece optical system includes optical elements having two lens functions, providing air spacing between them and has a positive refracting power as a whole.

In order to increase the angle of emergence, it is only necessary to increase the size of an image obtained by the objective optical system, that is, the size of the field frame, or to reduce the focal length of the eyepiece optical system. However, if the field frame is enlarged with respect to the focal length of the eyepiece optical system,

the burden of correction for aberration to the eyepiece optical system will be increased, and it becomes difficult to hold good performance with a single lens. If three or more optical elements are used, it becomes difficult to obtain compactness of the whole of the real image mode finder optical system. Hence, in order to diminish the size of the entire system including the objective optical system, it is desirable to reduce the focal length of the eyepiece optical system. However, when the focal length of the eyepiece optical system is reduced, the distance on the optical axis between the front principal point of the eyepiece optical system and the field frame is diminished, and, for example, space for arranging the optical elements of the image erecting means is narrowed.

Thus, in view of good performance, space for placing the image erecting means, and compactness of the whole of the real image mode finder optical system, it is desirable that the eyepiece optical system, as mentioned above, is constructed with the optical elements having two lens functions, providing air spacing between them.

Furthermore, it is desirable that the real image mode finder optical system of the present invention is designed so that the eyepiece optical system includes, in order from the object side, a prism which has the lens function, at least, with respect to the exit surface and bears a part of an image erecting function and a single positive lens component.

As mentioned above, when an optical element on the field frame side of the eyepiece optical system is constructed with the prism which bears a part of the image erecting function, space can be effectively utilized. Moreover, when the lens function is imparted to the prism separated from the field frame, the degree of a contribution to the focal length of the eyepiece optical system is increased, and it becomes easy to reduce the focal length of the eyepiece optical system.

It is desirable that the real image mode finder optical system of the present inven-

tion is designed to impart the lens function to the entrance surface of the prism of the eyepiece optical system.

Since the entrance surface of the prism of the eyepiece optical system is located close to the field frame, the degree of a contribution to the focal length of the eyepiece optical system is low. However, correction for aberration, notably for distortion, and a pupil combination of the objective optical system and the eyepiece optical system are favorably compatible.

It is desirable that the real image mode finder optical system is designed so that the reflecting surface of the prism of the eyepiece optical system is configured as a totally reflecting surface.

As described above, when total reflection is utilized for the reflecting surface of the prism, the transmittance of the entire system of the finder can be improved accordingly.

It is desirable that the real image mode finder optical system of the present invention is constructed so that the positive lens of the eyepiece optical system is capable of making diopter adjustment in accordance with an observer's diopter.

According to the present invention, a change of the diopter required is obtained with a small amount of adjustment. Since the diopter can be adjusted by the positive lens, unlike an element in which the optical axis is bent as in the prism, the adjustment can be easily made.

In this case, it is favorable that the real image mode finder optical system of the present invention satisfies Condition (2).

Condition (2) is provided for the purpose of ensuring a space for placing the image erecting means and compactness of the whole of the real image mode finder optical system in a state where Condition (1) is satisfied.

If the lower limit of Condition (2) is passed, a distance on the optical axis be-

tween the front principal point of the eyepiece optical system and the field frame will be reduced and at the same time, the finder magnification will be as low as 1× or less. Therefore, a distance on the optical axis between the rear principal point of the objective optical system and the field frame is also reduced, and it becomes difficult to place the image erecting means, which is not favorable.

On the other hand, beyond the upper limit of Condition (2), the maximum width mh of the field frame must be enlarged to increase the angle of emergence. In this case, the objective optical system becomes bulky and the balance between the angle of emergence and the size of the real image mode finder ceases to be kept, which is unfavorable.

It is more desirable that the real image mode finder optical system satisfies Condition (3).

According to the present invention, when the objective optical system is designed to have the focal length shorter than that of the eyepiece optical system, the magnification of the real image mode finer optical system can be reduced to 1× or less, and as a result, the angle of visual field can be increased.

When the objective optical system is constructed so that its focal length can be changed, a constant angle of emergence can be obtained, without changing the size of the field frame, even when the magnification is changed.

When the angle of emergence is increased, the phenomenon of a so-called diopter shift will occur if the back focal position is shifted. However, when at least two lens units are moved along different paths to change the magnification, the back focal position of the objective optical system can be kept to be nearly constant.

At least four reflecting surfaces are required for the image erecting means, and thus if the image erecting means is constructed with four reflecting surfaces, space efficiency can be improved. When three of four reflecting surfaces constituting the

image erecting means are placed in the objective optical system, the burden of a space for placing the image erecting means to the eyepiece optical system is lessened, and the number of optical elements constituting the eyepiece optical system can be reduced. Thus, according to the present invention, the focal length of the eyepiece optical system can be completely reduced, and aberration characteristics are easily improved. Also, the objective optical system has a large number of lenses because of the magnification change, and hence can be designed to ensure a space for incorporating three reflecting surfaces in the objective optical system. Consequently, a real image mode finder optical system which has a large angle of emergence and is compact in design can be constructed in a state where the arrangement of the eyepiece optical system is simplified.

The image erecting means including the three reflecting surfaces is constructed with two prisms so that each of the prisms has at least one reflecting surface and one of the entrance surface and the exit surface of each prism is configured as a curved surface with finite curvature.

When the image erecting means including the three reflecting surfaces of the objective optical system is constructed with two prisms so that one of the entrance surface and the exit surface of each prism has a curvature, a lens function, such as a contribution to the focal length or correction for aberration, and an image erecting function can be exerted in the same space.

As mentioned above, when the objective optical system is designed to have the focal length shorter than that of the eyepiece optical system, the magnification of the real image mode finer optical system can be reduced to 1× or less, and as a result, the angle of visual field can be increased. Condition (1) in the present invention is related to the angle of emergence.

Below the lower limit of Condition (1), the image can be seen only in small size.

On the other hand, beyond the upper limit of Condition (1), it becomes difficult to grasp the entire area of the visual field, for example, to quickly determine a picture composition.

When the objective optical system is constructed so that its focal length can be changed, a constant angle of emergence can be obtained, without changing the size of the field frame, even when the magnification is changed.

When the angle of emergence is increased, the phenomenon of a so-called diopter shift will occur if the back focal position is shifted. However, when at least two lens units are moved along different paths to change the magnification, the back focal position of the objective optical system can be kept to be nearly constant.

At least four reflecting surfaces are required for the image erecting means, and thus if the image erecting means is constructed with four reflecting surfaces, space efficiency can be improved. When the image erecting means is placed in the objective optical system, the burden of a space for placing the image erecting means to the eyepiece optical system is eliminated, and the eyepiece optical system can be constructed with a small number of lenses. Consequently, the focal length of the eyepiece optical system can be completely reduced, and aberration characteristics are easily improved.

Also, the objective optical system has a large number of lenses because of the magnification change, and hence the image erecting means can be constructed with comparative ease.

It is desirable that the real image mode finder optical system of the present invention is constructed so that the objective optical system comprises, in order from the object side, s first unit with a negative refracting power, moved when the magnification is changed; a second unit with a positive refracting power, moved when the magnification is changed; a third unit with a negative refracting power, moved when the

magnification is changed; and a fourth unit with a positive refracting power, fixed when the magnification is change and including four reflecting surfaces.

According to the present invention, it becomes easy to achieve compactness of the whole of the real image mode finder optical system and to obtain favorable aberration and a large angle of emergence. Also, the four reflecting surfaces of the fourth unit constitute the image erecting means.

In the real image mode finder optical system, it is desirable that the fourth unit includes two prisms so that each of the prisms has at least one reflecting surface and one of the entrance surface and the exit surface of each prism is configured as a curved surface with finite curvature.

According to the present invention, a lens function, such as a contribution to the focal length or correction for aberration, as the fourth unit of the objective optical system and an image erecting function can be exerted in the same space.

Furthermore, it is desirable that the real image mode finder optical system of the present invention is constructed so that one of the two prisms has totally reflecting surfaces.

As mentioned above, when total reflection is utilized as far as possible with respect to the reflecting surfaces of the prism, the transmittance of the entire finder can be improved accordingly.

In the real image mode finder optical system, it is desirable that each of the first unit, the second unit, and the third unit is constructed with a single lens.

According to the present invention, it becomes easy to achieve compactness of the whole of the real image mode finder optical system.

It is desirable that the real image mode finder optical system of the present invention is constructed so that the eyepiece optical system has a lens which is capable of making diopter adjustment to an observer's diopter.

According to the present invention, a change of the diopter required is obtained with a small amount of adjustment, with little deterioration of performance. Since the diopter can be adjusted by the lens, unlike an element in which the optical axis is bent as in the prism, the adjustment can be easily made.

In this case, it is favorable that the real image mode finder optical system of the present invention satisfies Condition (2).

Condition (2) is provided for the purpose of ensuring a space for placing the image erecting means and compactness of the whole of the real image mode finder optical system in a state where Condition (1) is satisfied.

If the lower limit of Condition (2) is passed, a distance on the optical axis between the front principal point of the eyepiece optical system and the field frame will be reduced and at the same time, the finder magnification will be as low as 1× or less. Therefore, a distance on the optical axis between the rear principal point of the objective optical system and the field frame is also reduced, and it becomes difficult to place the image erecting means, which is not favorable.

On the other hand, beyond the upper limit of Condition (2), the maximum width mh of the field frame must be enlarged to increase the angle of emergence. In this case, the objective optical system becomes bulky and the balance between the angle of emergence and the size of the real image mode finder ceases to be kept, which is unfavorable.

In this case, it is more desirable that the real image mode finder optical system satisfies Condition (3).

According to the present invention, when the objective optical system is designed to have the focal length shorter than that of the eyepiece optical system, the magnification of the real image mode finer optical system can be reduced to 1× or less, and as a result, the angle of visual field can be increased.

When the objective optical system is constructed so that its focal length can be changed, a constant angle of emergence can be obtained, without changing the size of the field frame, even when the magnification is changed.

When the angle of emergence is increased, the phenomenon of a so-called diopter shift will occur if the back focal position is shifted. However, when at least two lens units are moved along different paths to change the magnification, the back focal position of the objective optical system can be kept to be nearly constant.

At least four reflecting surfaces are required for the image erecting means, and thus if the image erecting means is constructed with four reflecting surfaces, space efficiency can be improved. When the image erecting means is placed in the objective optical system, the burden of a space for placing the image erecting means to the eyepiece optical system is eliminated, and the eyepiece optical system can be constructed with a small number of lenses. According to the present invention, the focal length of the eyepiece optical system can be completely reduced, and aberration characteristics are easily improved. Also, the objective optical system has a large number of lenses because of the magnification change, and hence the image erecting means can be constructed with comparative ease.

It is favorable that the photographing apparatus according to the present invention has the photographing optical system and the real image mode finder optical system which has been described.

The real image mode finder optical system according to the present invention is constructed to be independent of the photographing optical system and has, in order from the object side, an objective optical system with a positive refracting power, a field frame located in the proximity of the imaging position of the objective optical system, and an eyepiece optical system with a positive refracting power. The real image mode finder optical system includes an image erecting means, the objective

optical system is capable of having the focal length shorter than that of the eyepiece optical system, and the eyepiece optical system has at least one lens. In this case, a most observer's pupil-side lens satisfies the following condition:

$$\nu > 70 \quad (4)$$

where ν is the Abbe's number of the most observer's pupil-side lens.

The real image mode finder optical system according to the present invention is constructed to be independent of the photographing optical system and has, in order from the object side, an objective optical system with a positive refracting power, a field frame located in the proximity of the imaging position of the objective optical system, and an eyepiece optical system with a positive refracting power. The real image mode finder optical system includes an image erecting means, the objective optical system is capable of having the focal length shorter than that of the eyepiece optical system, and the eyepiece optical system has at least one lens. In this case, the real image mode finder optical system satisfies Conditions (1) and (4).

The real image mode finder optical system according to the present invention is constructed to be independent of the photographing optical system and has, in order from the object side, an objective optical system with a positive refracting power, a field frame located in the proximity of the imaging position of the objective optical system, and an eyepiece optical system with a positive refracting power. The real image mode finder optical system includes an image erecting means, the objective optical system is capable of having the focal length shorter than that of the eyepiece optical system, and the eyepiece optical system has a cemented lens component including a positive lens element and a negative lens element at the most observer's pupil-side position.

When the objective optical system is designed to have the focal length shorter than that of the eyepiece optical system, the magnification of the real image mode fin-

er optical system can be reduced to 1× or less, and as a result, the angle of visual field can be increased.

When Condition (4) is satisfied, chromatic aberration of magnification produced in the eyepiece optical system can be suppressed.

By constructing the finder optical system to be independent of the photographing optical system, the value of a maximum width mh of the field frame can be set, irrespective of the size of an imaging plane. This is particularly advantageous for compact design of the eyepiece optical system and for the placement of an image erecting means.

When the objective optical system is designed to have the focal length shorter than that of the eyepiece optical system, the magnification of the real image mode finer optical system can be reduced to 1× or less, and as a result, the angle of visual field can be increased. Condition (1) in the present invention is related to the angle of emergence. In order to increase the angle of emergence, it is only necessary to increase the size of an image obtained by the objective optical system, that is, the size of the field frame, or to reduce the focal length of the eyepiece optical system.

Below the lower limit of Condition (1), the image can be seen only in small size. On the other hand, beyond the upper limit of Condition (1), it becomes difficult to grasp the entire area of the visual field, for example, to quickly determine a picture composition.

When Condition (4) is satisfied, chromatic aberration of magnification produced in the eyepiece optical system can be suppressed.

By constructing the finder optical system to be independent of the photographing optical system, the value of a maximum width mh of the field frame can be set, irrespective of the size of an imaging plane. This is particularly advantageous for compact design of the eyepiece optical system and for the placement of an image erecting

means.

It is favorable that the real image mode finder optical system of the present invention is constructed so that the focal length of the objective optical system is variable, and when the magnification of the finder is changed, at least two lens units are moved along different paths.

When the objective optical system is constructed so that its focal length can be changed, a constant angle of emergence can be obtained, without changing the size of the field frame, even when the magnification is changed.

When the angle of emergence is increased, the phenomenon of a so-called diopter shift will occur if the back focal position is shifted. However, when at least two lens units are moved along different paths to change the magnification, the back focal position of the objective optical system can be kept to be nearly constant.

It is desirable that the real image mode finder optical system of the present invention satisfies Condition (2).

Condition (2) is provided for the purpose of ensuring a space for placing the image erecting means and compactness of the whole of the real image mode finder optical system in a state where Condition (1) is satisfied.

If the lower limit of Condition (2) is passed, a distance on the optical axis between the front principal point of the eyepiece optical system and the field frame will be reduced and at the same time, the finder magnification will be as low as 1× or less. Therefore, a distance on the optical axis between the rear principal point of the objective optical system and the field frame is also reduced, and it becomes difficult to place the image erecting means, which is not favorable.

On the other hand, beyond the upper limit of Condition (2), the maximum width mh of the field frame must be enlarged to increase the angle of emergence. In this case, the objective optical system becomes bulky and the balance between the angle of

emergence and the size of the real image mode finder ceases to be kept, which is unfavorable.

It is more desirable that the real image mode finder optical system satisfies Condition (3).

It is favorable that the real image mode finder optical system is constructed so that the objective optical system includes three reflecting surfaces of the image erecting means and the eyepiece optical system includes one reflecting surface of the image erecting means to erect an image with four reflecting surfaces comprised of the three reflecting surfaces of the objective optical system and the one reflecting surface of the eyepiece optical system.

At least four reflecting surfaces are required for the image erecting means, and thus if the image erecting means is constructed with four reflecting surfaces, space efficiency can be improved. When three of four reflecting surfaces constituting the image erecting means are placed in the objective optical system, the burden of a space for placing the image erecting means to the eyepiece optical system is lessened, and the number of optical elements constituting the eyepiece optical system can be reduced. Thus, according to the present invention, the focal length of the eyepiece optical system can be completely reduced, and aberration characteristics are easily improved. In particular, where the focal length of the objective optical system is variable, the objective optical system, which has a large number of lenses, can be designed to ensure a space for incorporating three reflecting surfaces in the objective optical system. Consequently, a real image mode finder optical system which has a large angle of emergence and is compact in design can be constructed in a state where the arrangement of the eyepiece optical system is simplified.

It is favorable that the real image mode finder optical system of the present invention is constructed so that the objective optical system has the image erecting

means including four reflecting surfaces to erect the image with the four reflecting surfaces of the objective optical system.

At least four reflecting surfaces are required for the image erecting means, and thus if the image erecting means is constructed with four reflecting surfaces, space efficiency can be improved. When the image erecting means is placed in the objective optical system, the burden of a space for placing the image erecting means to the eyepiece optical system is eliminated, and the eyepiece optical system can be constructed with a small number of lenses. According to the present invention, the focal length of the eyepiece optical system can be completely reduced, and aberration characteristics are easily improved. In particular, where the focal length of the objective optical system is variable, the number of lenses constituting the objective optical system is large, and hence the image erecting means can be constructed with comparative ease.

According to the present invention, when the objective optical system is designed to have the focal length shorter than that of the eyepiece optical system, the magnification of the real image mode finer optical system can be reduced to 1× or less, and as a result, the angle of visual field can be increased.

When the cemented lens component including the positive lens element and the negative lens element is placed on the observer's pupil side of the eyepiece optical system, chromatic aberration of magnification produced in the eyepiece optical system can be suppressed.

Also, by constructing the finder optical system to be independent of the photographing optical system, the value of a maximum width mh of the field frame can be set, irrespective of the size of an imaging plane. This is particularly advantageous for compact design of the eyepiece optical system and for the placement of an image erecting means.

The real image mode finder optical system according to the present invention is constructed to be independent of the photographing optical system and has, in order from the object side, an objective optical system with a positive refracting power, a field frame located in the proximity of the imaging position of the objective optical system, and an eyepiece optical system with a positive refracting power. The real image mode finder optical system includes an image erecting means, the objective optical system is capable of having the focal length shorter than that of the eyepiece optical system, and the eyepiece optical system has a cemented lens component including a positive lens element and a negative lens element on the observer's pupil side. In this case, it is favorable to satisfy Condition (1).

When the objective optical system is designed to have the focal length shorter than that of the eyepiece optical system, the magnification of the real image mode finer optical system can be reduced to 1× or less, and as a result, the angle of visual field can be increased. Condition (1) in the present invention is related to the angle of emergence. In order to increase the angle of emergence, it is only necessary to increase the size of an image obtained by the objective optical system, that is, the size of the field frame, or to reduce the focal length of the eyepiece optical system.

Below the lower limit of Condition (1), the image can be seen only in small size. On the other hand, beyond the upper limit of Condition (1), it becomes difficult to grasp the entire area of the visual field, for example, to quickly determine a picture composition.

When the cemented lens component including the positive lens element and the negative lens element is placed on the observer's pupil side of the eyepiece optical system, chromatic aberration of magnification produced in the eyepiece optical system can be suppressed.

Also, by constructing the finder optical system to be independent of the photo-

graphing optical system, the value of a maximum width mh of the field frame can be set, irrespective of the size of an imaging plane. This is particularly advantageous for compact design of the eyepiece optical system and for the placement of an image erecting means.

It is favorable that the real image mode finder optical system of the present invention is constructed so that the focal length of the objective optical system is variable, and when the magnification of the finder is changed, at least two lens units are moved along different paths.

When the objective optical system is constructed so that its focal length can be changed, a constant angle of emergence can be obtained, without changing the size of the field frame, even when the magnification is changed.

When the angle of emergence is increased, the phenomenon of a so-called diopter shift will occur if the back focal position is shifted. However, when at least two lens units are moved along different paths to change the magnification, the back focal position of the objective optical system can be kept to be nearly constant.

It is also favorable that the real image mode finder optical system of the present invention satisfies the following condition:

$$\nu p - \nu n > 10 \tag{5}$$

where νp is the Abbe's number of the positive lens element constituting the cemented lens component on the observer's pupil side of the eyepiece optical system and νn is the Abbe's number of the negative lens element constituting the cemented lens component.

As mentioned above, when the finder optical system is designed to satisfy Condition (5), chromatic aberration of magnification produced in the eyepiece optical system can be suppressed.

It is more desirable that the real image mode finder optical system of the present

invention satisfies the following condition:

$$\nu p - \nu n > 20 \quad (6)$$

It is favorable that that the photographing apparatus according to the present invention has the photographing optical system and the real image mode finder optical system which has been described.

Also, in the above description, where the reflecting surface is configured as a roof reflecting surface, it is assumed that the roof reflecting surface is constructed with two reflecting surfaces.

The real image mode finder optical system according to the present invention includes, in order from the object side, an objective optical system with a positive refracting power, a field frame located in the proximity of the imaging position of the objective optical system, and an eyepiece optical system with a positive refracting power. The real image mode finder optical system has an image erecting means, and the objective optical system includes, in order from the object side, a first unit with a negative refracting power, a second unit with a positive refracting power, a third unit with a negative refracting power, and a fourth unit with a positive refracting power so that the magnification of the finder is changed, ranging from the wide-angle position to the telephoto position, by simply moving the second unit toward the object side and the third unit toward the eyepiece optical system. In this case, the finder optical system satisfies Condition (2).

The real image mode finder optical system according to the present invention includes, in order from the object side, an objective optical system with a positive refracting power, a field frame located in the proximity of the imaging position of the objective optical system, and an eyepiece optical system with a positive refracting power. The real image mode finder optical system has an image erecting means, and the objective optical system includes, in order from the object side, a first unit with a

negative refracting power, a second unit with a positive refracting power, a third unit with a negative refracting power, and a fourth unit with a positive refracting power so that the magnification of the finder is changed, ranging from the wide-angle position to the telephoto position, by simply moving the second unit toward the object side and the third unit toward the eyepiece optical system. In this case, the finder optical system satisfies Condition (1).

The real image mode finder optical system according to the present invention includes, in order from the object side, an objective optical system with a positive refracting power, a field frame located in the proximity of the imaging position of the objective optical system, and an eyepiece optical system with a positive refracting power. The real image mode finder optical system has an image erecting means, and the objective optical system is capable of having the focal length shorter than that of the eyepiece optical system. The eyepiece optical system includes, in order from the object side, a prism unit with a positive refracting power and a lens unit with a positive refracting power so that a most field-frame-side surface of the prism unit with a positive refracting power has a positive refracting power and is configured as an aspherical surface with a negative refracting power on the periphery thereof.

In order to increase the angle of emergence, it is only necessary to increase the size of an image obtained by the objective optical system, that is, the size of the field frame, or to reduce the focal length of the eyepiece optical system. However, if the field frame is enlarged with respect to the focal length of the eyepiece optical system, the objective optical system must be also enlarged. Moreover, since the burden of correction for aberration to the eyepiece optical system will be increased, it becomes difficult that good performance of the eyepiece optical system and compactness due to a simple arrangement are compatible with each other. Thus, in order to keep the size of the finder compact and increase the angle of emergence, it is desirable to reduce the

focal length of the eyepiece optical system.

However, when the focal length of the eyepiece optical system is reduced, the distance on the optical axis between the front principal point of the eyepiece optical system and the field frame is diminished, and, for example, space for arranging the optical elements of the image erecting means is narrowed. Consequently, it is necessary that the back focal distance of the objective optical system is increased to place the image erecting means there.

Thus, in the present invention, the objective optical system is designed to have, in order to the object side, the first unit with a negative refracting power, the second unit with a positive refracting power, the third unit with a negative refracting power, and the fourth unit with a positive refracting power. In this way, the back focal distance of the objective optical system is increased.

When the objective optical system is constructed as mentioned above, the focal length of the eyepiece optical system can be reduced, and a real image mode finder optical system which has a large angle of emergence and is compact in design can be obtained.

Condition (2) defines a condition for maintaining the balance of size between the angle of emergence and the finder. Below the lower limit of Condition (2), the distance on the optical axis between the front principal point of the eyepiece optical system and the field frame is reduced, and it becomes difficult to ensure the space for placing the image erecting means. In addition, a diopter shift due to the position shift of the field frame in the direction of the optical axis is increased.

On the other hand, beyond the upper limit of Condition (2), the objective optical system becomes bulky because the image formed by objective optical system must be enlarged to increase the angle of emergence. Consequently, the balance between the angle of emergence and the size of the finder ceases to be kept, which is unfavorable.

When the magnification of the finder is changed, it is necessary that a variable magnification function is chiefly imparted to one of at least two moving lens units and a diopter correcting function involved in the magnification change is chiefly imparted to the other. In this case, the amount of movement of the lens unit having the variable magnification function becomes larger than that of the lens unit having the diopter correcting function, and a mechanism for movement is liable to be complicated and oversized.

Thus, in the present invention, the finder optical system is constructed so that the magnification is changed, ranging from the wide-angle position to the telephoto position, by simply moving the second unit toward the object side and the third unit toward the eyepiece side.

By doing so, both the variable magnification function and the diopter correcting function can be shared between the second unit and the third unit. Hence, the amount of movement of each of the second and third units where the magnification is change can be kept to a minimum, and compactness of the mechanism for movement is obtained.

In this case, it is more desirable that the real image mode finder optical system satisfies Condition (3).

As mentioned above, in order to increase the angle of emergence, it is only necessary to increase the size of an image obtained by the objective optical system, that is, the size of the field frame, or to reduce the focal length of the eyepiece optical system. However, if the field frame is enlarged with respect to the focal length of the eyepiece optical system, the objective optical system must be also enlarged. Moreover, since the burden of correction for aberration to the eyepiece optical system will be increased, it becomes difficult that good performance of the eyepiece optical system and compactness due to a simple arrangement are compatible with each other. Thus, in order

to keep the size of the finder compact and increase the angle of emergence, it is desirable to reduce the focal length of the eyepiece optical system.

However, when the focal length of the eyepiece optical system is reduced, the distance on the optical axis between the front principal point of the eyepiece optical system and the field frame is diminished, and, for example, space for arranging the optical elements of the image erecting means is narrowed. Consequently, it is necessary that the back focal distance of the objective optical system is increased to place the image erecting means there.

Thus, in the present invention, the objective optical system is designed to have, in order to the object side, the first unit with a negative refracting power, the second unit with a positive refracting power, the third unit with a negative refracting power, and the fourth unit with a positive refracting power. In this way, the back focal distance of the objective optical system is increased.

When the objective optical system is constructed as mentioned above, the focal length of the eyepiece optical system can be reduced, and a real image mode finder optical system which has a large angle of emergence and is compact in design can be obtained.

Condition (1) is related to the angle of emergence. Below the lower limit of Condition (1), the image can be seen only in small size. On the other hand, beyond the upper limit of Condition (1), it becomes difficult to grasp the entire area of the visual field, for example, to quickly determine a picture composition.

When the magnification of the finder is changed, it is necessary that the variable magnification function is chiefly imparted to one of at least two moving lens units and the diopter correcting function involved in the magnification change is chiefly imparted to the other. In this case, the amount of movement of the lens unit having the variable magnification function becomes larger than that of the lens unit having the diopter

correcting function, and a mechanism for movement is liable to be complicated and oversized.

Thus, in the present invention, the finder optical system is constructed so that the magnification is changed, ranging from the wide-angle position to the telephoto position, by simply moving the second unit toward the object side and the third unit toward the eyepiece optical system.

By doing so, both the variable magnification function and the diopter correcting function can be shared between the second unit and the third unit. Hence, the amount of movement of each of the second and third units where the magnification is change can be kept to a minimum, and compactness of the mechanism for movement is obtained.

In this case, it is more desirable that the present invention satisfies the following condition:

$$0.57 < mh / fe < 1 \quad (7)$$

As described above, when the objective optical system is designed to have the focal length shorter than that of the eyepiece optical system, the magnification of the real image mode finer optical system can be reduced to 1× or less, and as a result, the angle of visual field can be increased.

When the eyepiece optical system is designed to have the prism unit, a part of the image erecting means can be shared to the eyepiece optical system, and space can be effectively utilized. When the eyepiece optical system is constructed with the unit having a positive refracting power, the diopter can be adjusted in accordance with the observer's diopter.

In order to keep the size of the finder compact and increase the angle of emergence, it is desirable to reduce the focal length of the eyepiece optical system. Further, in order to reduce the focal length of the eyepiece optical system, it is desirable to

increase the positive refracting power of the optical element constituting the eyepiece optical system.

However, if the most field-frame-side surface of the eyepiece optical system is configured so that the positive refracting power is increased, and a marginal beam in the proximity of the field frame is rendered nearly parallel to the optical axis, the size of the eyepiece optical system in its radial direction will be increased. On the other hand, if the most field-frame-side surface of the eyepiece optical system is configured so that the positive refracting power is increased, and at the same time, the size of the eyepiece optical system in its radial direction is diminished, the angle of inclination will be increased. Consequently, the marginal beam of the first unit at the wide-angle position is separated from the optical axis, and hence the diameter of the first unit must be enlarged.

Thus, when the most field-frame-side surface of the eyepiece optical system has a positive refracting power and is configured as an aspherical surface with a negative refracting power on its periphery, the diameter of the first unit can be diminished. Moreover, correction for aberration, notably for distortion, is favorably compatible with a pupil combination of the objective optical system and the eyepiece optical system, notably in an off-axis.

In the real image mode finder optical system of the present invention, it is desirable that the eyepiece optical system includes, in order from the object side, a prism unit with a positive refracting power and a lens unit with a positive refracting power so that a most field-frame-side surface of the prism unit with a positive refracting power has a positive refracting power and is configured as an aspherical surface with a negative refracting power on its periphery.

As mentioned above, when the eyepiece optical system is designed to have the prism unit, a part of the image erecting means can be shared to the eyepiece optical

system, and space can be effectively utilized. When the eyepiece optical system is constructed with the lens unit having a positive refracting power, the diopter can be adjusted in accordance with the observer's diopter.

In order to reduce the focal length of the eyepiece optical system, it is desirable to increase the positive refracting power of the optical element constituting the eyepiece optical system.

However, if the most field-frame-side surface of the eyepiece optical system is configured so that the positive refracting power is increased, and a marginal beam in the proximity of the field frame is rendered nearly parallel to the optical axis, the size of the eyepiece optical system in its radial direction will be increased. On the other hand, if the most field-frame-side surface of the eyepiece optical system is configured so that the positive refracting power is increased, and at the same time, the size of the eyepiece optical system in its radial direction is diminished, the angle of inclination will be increased. Consequently, the marginal beam of the first unit at the wide-angle position is separated from the optical axis, and hence the diameter of the first unit must be enlarged.

Thus, when the most field-frame-side surface of the eyepiece optical system has a positive refracting power and is configured as an aspherical surface with a negative refracting power on its periphery, the diameter of the first unit can be diminished. Moreover, correction for aberration, notably for distortion, is favorably compatible with a pupil combination of the objective optical system and the eyepiece optical system, notably in an off-axis.

In the real image mode finder optical system of the present invention, it is favorable that the negative refracting power on the periphery of the most field-frame-side surface of the prism unit with a positive refracting power satisfies the following condition:

$$-0.7\ (1/\mathrm{mm}) < \phi(mh/2) < 0\ (1/\mathrm{mm}) \tag{8}$$

where $\phi(mh/2)$ is a refracting power at a height mh/2 in a direction normal to the optical axis of the aspherical surface.

As described above, when Condition (8) is satisfied, the negative refracting power on the periphery of the most field-frame-side surface of the positive prism unit can be optimized.

Also, a refracting power $\phi(y)$ at a height y of the aspherical surface is obtained as follows. When z is taken as the coordinate in the direction of the optical axis, y is taken as the coordinate normal to the optical axis, r denotes the radius of curvature, K denotes a conic constant, and A_4, A_6, A_8, and A_{10} denote aspherical coefficients, the configuration of the aspherical surface is expressed by the following equation:

$$z = (y^2/r) / [1 + \sqrt{\{1-(1+K)(y/r)^2\}}] + A_4y^4 + A_6y^6 + A_8y^8 + A_{10}y^{10}$$

Also, first-order differential dz/dy and second-order differential d^2z/dy^2 are given from the following formulas:

$$dz/dy = (y/r)/[\sqrt{\{1-(1+K)(y/r)^2\}}] + 4A_4y^3 + 6A_6y^5 + 8A_8y^7 + 10A_{10}y^9$$

$$d^2z/dy^2 = (1/r)/[\{1-(1+K)(y/r)^2\}^{3/2}] + 12A_4y^2 + 30A_6y^4 + 56A_8y^6 + 90A_{10}y^8$$

In this case, the refracting power $\phi(y)$ at the height y of the aspherical surface is obtained from the following formula:

$$\phi(y) = (n_2 - n_1)/r_{asp}$$

where n_1 is the refractive index of the aspherical surface on the object side thereof and n_2 is the refractive index on the image side.

Also, r_{asp} is defined as

$$r_{asp} = [\{1+(dz/dy)^2\}^{3/2}]/(d^2z/dy^2)$$

It is favorable that the real image mode finder optical system of the present invention is constructed so that the objective optical system has at least two lens units, the focal length of the objective optical system is variable, and when the magnification

is changed, the at least two lens units are moved along different paths.

When the objective optical system is constructed so that its focal length can be changed, a constant angle of emergence can be obtained, without changing the size of the field frame, even when the magnification is changed.

When the angle of emergence is increased, the phenomenon of a so-called diopter shift will occur if the back focal position is shifted. However, when at least two lens units are moved along different paths to change the magnification, the back focal position of the objective optical system can be kept to be nearly constant.

It is favorable that the photographing apparatus according to the present invention has the photographing optical system and the real image mode finder optical system which has been described.

Also, in the above description, where the reflecting surface is configured as a roof reflecting surface, it is assumed that the roof reflecting surface is constructed with two reflecting surfaces.

The real image mode finder optical system according to the present invention includes, in order from the object side, an objective optical system which has a positive refracting power and changes the magnification of the finder, a field frame located in the proximity of the imaging position of the objective optical system, and an eyepiece optical system with a positive refracting power. The real image mode finder optical system has an image erecting means, and the objective optical system includes, in order from the object side, a front unit with a negative refracting power and a rear unit with a positive refracting power. The front unit is constructed with a plurality of lens units so that the magnification is changed, ranging from the wide-angle position to the telephoto position, by moving at least two of the plurality of lens units. The rear unit is constructed with a plurality of prism units with positive refracting powers so that at least one of surfaces opposite to one another, of the plurality of prism units is config-

ured to be convex.

The real image mode finder optical system according to the present invention includes, in order from the object side, an objective optical system which has a positive refracting power and changes the magnification of the finder, a field frame located in the proximity of the imaging position of the objective optical system, and an eyepiece optical system with a positive refracting power. The real image mode finder optical system has an image erecting means, and the objective optical system includes, in order from the object side, a first unit with a negative refracting power, a second unit with a positive refracting power, a third unit with a negative refracting power, and a fourth unit with a positive refracting power. The fourth unit is comprised of a fourth front sub-unit with a positive refracting power and a fourth rear sub-unit with a positive refracting power, and the magnification is changed, ranging from the wide-angle position to the telephoto position, by moving the second unit and the third unit. Each of the first, second, and third units is constructed with a lens, and each of the fourth front and rear sub-units is constructed with a prism so that at least one of surfaces opposite to each other, of the fourth front and rear sub-units is configured to be convex.

In the above construction, the real image mode finder optical system is such that the fourth front sub-unit is comprised of a single prism and has a single reflecting surface.

In order to increase the angle of emergence, it is only necessary to increase the size of an image obtained by the objective optical system, that is, the size of the field frame, or to reduce the focal length of the eyepiece optical system. However, if the field frame is enlarged with respect to the focal length of the eyepiece optical system, the objective optical system must be also enlarged. Moreover, since the burden of correction for aberration to the eyepiece optical system will be increased, it becomes difficult that good performance of the eyepiece optical system and compactness due to

a simple arrangement are compatible with each other. Thus, in order to keep the size of the finder compact and increase the angle of emergence, it is desirable to reduce the focal length of the eyepiece optical system.

However, when the focal length of the eyepiece optical system is reduced, the distance on the optical axis between the front principal point of the eyepiece optical system and the field frame is diminished, and, for example, space for arranging the optical elements of the image erecting means is narrowed, so that the reflecting surface to be placed is limited to one. Consequently, it is necessary that the back focal distance of the objective optical system is increased to place the image erecting means there.

Thus, in the present invention, the objective optical system is designed to have, in order to the object side, a front unit with a negative refracting power, including a plurality of lens units and changing the magnification by moving at least two lens units thereof and a rear unit with a positive refracting power comprised of a plurality of prism units with positive refracting powers.

As mentioned above, when the objective optical system is designed to be of a retrofocus type, the back focal distance of the objective optical system can be increased. Moreover, when the rear unit with a positive refracting power is constructed with the prism units, the image erecting means can be shared. Thus, according to the present invention, the focal length of the eyepiece optical system can be reduced, and a real image mode finder optical system which has a large angle of emergence and is compact in design can be achieved.

In the case where the variable magnification ratio of the finder optical system is increased to particularly extend the variable magnification range to the wide-angle side, a high refracting power is required for the rear unit with a positive refracting power. The inclination of the marginal beam with respect to the optical axis where the mag-

nification is changed at the wide-angle position is large immediately after the beam emerges from the front unit with a negative refracting power. Hence, in order to make this inclined beam parallel in the proximity of the field frame, a great positive refracting power is required on the rear side of the front unit with a negative refracting power. In this case, it is desirable that the great positive refracting power is shared among a plurality of surfaces because the performance of the objective optical system is improved.

The rear unit with a positive refracting power comprised of a plurality of prism units with positive refracting powers is placed on the eyepiece side of the front unit with a negative refracting power, and at least one of surfaces opposite to one another, of the plurality of prism units with positive refracting powers is configured to be convex. By doing so, the positive refracting power can be shared to the entrance or exit surface of each of the plurality of prism units with positive refracting powers, and thus the performance of the objective optical system can be improved.

When the magnification is changed by moving at least two lens units, the variable magnification function and the diopter correcting function involved in the magnification change can be exercised.

When the angle of emergence is increased, the diopter shift is liable to occur. However, by moving at least two lens units of the front unit, the diopter shift involved in the magnification change can be corrected.

As mentioned above, in order to increase the angle of emergence, it is only necessary to increase the size of an image obtained by the objective optical system, that is, the size of the field frame, or to reduce the focal length of the eyepiece optical system. However, if the field frame is enlarged with respect to the focal length of the eyepiece optical system, the objective optical system must be also enlarged. Moreover, since the burden of correction for aberration to the eyepiece optical system will be increased,

it becomes difficult that good performance of the eyepiece optical system and compactness due to a simple arrangement are compatible with each other. Thus, in order to keep the size of the finder compact and increase the angle of emergence, it is desirable to reduce the focal length of the eyepiece optical system.

However, when the focal length of the eyepiece optical system is reduced, the distance on the optical axis between the front principal point of the eyepiece optical system and the field frame is diminished, and, for example, space for arranging the optical elements of the image erecting means is narrowed, so that the reflecting surface to be placed is limited to one. Consequently, it is necessary that the back focal distance of the objective optical system is increased to place the image erecting means there.

Thus, in the present invention, the objective optical system is designed to have, in order to the object side, the first unit with a negative refracting power, the second unit with a positive refracting power, the third unit with a negative refracting power, and the fourth unit with a positive refracting power so that the fourth unit includes the fourth front sub-unit with a positive refracting power and the fourth rear sub-unit with a positive refracting power.

As described above, when the positive refracting power is imparted to each of the fourth front sub-unit and the fourth rear sub-unit, the back focal distance of the objective optical system can be increased. Moreover, when the fourth front and rear sub-units are constructed with prisms, the function of the image erecting means can be shared. Thus, according to the present invention, the focal length of the eyepiece optical system can be reduced, and a real image mode finder optical system which has a large angle of emergence and is compact in design can be obtained.

In the case where In the case where the variable magnification ratio of the finder optical system is increased to particularly extend the variable magnification range to

the wide-angle side, high refracting powers are required for the units with positive refracting powers on the eyepiece side of the third unit. The inclination of the marginal beam with respect to the optical axis where the magnification is changed at the wide-angle position is large immediately after the beam emerges from the front unit with a negative refracting power. Hence, in order to make this inclined beam parallel in the proximity of the field frame, a great positive refracting power is required on the rear side of the front unit with a negative refracting power. In this case, it is desirable that the great positive refracting power is shared among a plurality of surfaces because the performance of the objective optical system is improved.

When the prism units of the fourth front and rear sub-units with two positive refracting powers are arranged on the eyepiece side of the third unit and at least one of opposite surfaces of the fourth front and rear sub-units is configured to be convex, the positive refracting power can be shared to at least one of opposite surfaces of the fourth front and rear sub-units, and hence the performance of the objective optical system can be improved.

When the magnification is changed by moving at least two units, the variable magnification function and the diopter correcting function involved in the magnification change can be exercised.

When the angle of emergence is increased, the diopter shift is liable to occur. However, by moving the second and third units, the diopter shift involved in the magnification change can be corrected.

In order that the thickness of a camera is reduced to provide a compact camera, it is desirable that a position where the most object-side optical axis of the image erecting means, that is, the position of a reflecting surface, is brought close to the object side. When the magnification is changed, the image erecting means remains fixed and thereby the arrangement of the finder is simplified. Thus, it is desirable that the

fourth front sub-unit with a positive refracting power has a reflecting surface.

On the other hand, in order to increase the back focal distance of the objective optical system, it is desired that most of the reflecting surfaces having positive refracting powers shared between the fourth front and rear sub-units are arranged together at a distance away from the field frame.

When the objective optical system is constructed so that the fourth front sub-unit has a single reflecting surface as mentioned above, the opposite surfaces of the fourth front and rear sub-units can be arranged along the length of the fourth front sub-unit including one reflecting surface. Consequently, compactness of the camera and the back focal distance of the objective optical system can be ensured.

In the real image mode finder optical system of the present invention, it is favorable that the fourth rear sub-unit is constructed with a single prism and has two reflecting surfaces.

At least four reflecting surfaces are required for the image erecting means, and thus if the image erecting means is constructed with four reflecting surfaces, space efficiency can be improved. In this case, when three of four reflecting surfaces constituting the image erecting means are placed in the objective optical system, the burden of a space for placing the image erecting means to the eyepiece optical system is lessened, and the number of optical elements constituting the eyepiece optical system can be reduced.

It is favorable that the real image mode finder optical system of the present invention satisfies the following condition:

$$-1.0 < MG45 < -0.5 \qquad (9)$$

where MG45 is a combined imaging magnification of the fourth front sub-unit and a fourth rear sub-unit at an object distance of 3 m.

When Condition (9) is satisfied, the balance between performance and size of the

objective optical system can be held. Below the lower limit of Condition (9), a combined refracting power of the first, second, and third units must be increased, and thus the fluctuation of aberration becomes heavy by movement of the second and third units for changing the magnification. On the other hand, beyond the upper limit of Condition (9), a combined refracting power of the first, second, and third units must be reduced, and thus the diameter of the first unit will be particularly enlarged.

When the magnification is changed over the range from the wide-angle position to the telephoto position, it is favorable that the real image mode finder optical system satisfies the following condition:

$$-1.2 < \beta 3 < -0.8 \qquad (10)$$

where $\beta 3$ is the imaging magnification of the third unit in a state where the imaging magnification of the second unit is $-1\times$ at an object distance of 3 m.

The second and third units bear the variable magnification function and the diopter correcting function, but if the diopter correction is not completely made, the diopter shift will be produced. In particular, when the angle of emergence is increased, the diopter shift is liable to occur.

When the finder optical system is designed to satisfy Condition (10), a state where the imaging magnification of the second unit is $-1\times$ at an object distance of 3 m practically coincides with a state where the imaging magnification of the third unit is $-1\times$ at an object distance of 3 m when the magnification is changed over the range from the wide-angle position to the telephoto position. As a result, diopter correction can be favorably made over the whole range in which the magnification is changed.

In the real image mode finder optical system of the present invention, it is favorable that the second unit is constructed with a single lens and satisfies the following condition:

$$-0.6 < SF2 < 0.6 \qquad (11)$$

where $SF2 = (r3 + r4) / (r3 - r4)$, which is the shape factor of the second unit, r3 is the radius of curvature of the object-side surface of the second unit, and r4 is the radius of curvature of the eyepiece-side surface of the second unit.

When the finder optical system is designed to satisfy Condition (11), the fluctuation of performance where the magnification is changed can be suppressed. If the upper or lower limit of Condition (11) is passed, the fluctuation of aberration where the magnification is changed becomes heavy.

In the real image mode finder optical system of the present invention, it is desirable that each of the second and third units is constructed with a single lens and satisfies the following condition:

$$-1.9 < f2 / f3 < -1.0 \qquad (12)$$

where f2 is the focal length of the second unit and f3 is the focal length of the third unit.

Condition (12) defines a condition relative to the refracting powers of the second and third units for suppressing a change in performance where the magnification is changed. Below the lower limit of Condition (12), the refracting power of the third unit is increased, and the fluctuation of aberration where the magnification is changed becomes heavy. Beyond the upper limit of Condition (12), the refracting power of the second unit is increased, and the fluctuation of aberration where the magnification is changed becomes heavy.

It is favorable that the real image mode finder optical system of the present invention satisfies the following conditions at the same time:

$$-1.0 < fw / fFw < -0.4 \qquad (13)$$

$$-1.0 < fT / fFT < -0.4 \qquad (14)$$

where fFw is a combined focal length of the front unit with a negative refracting power at the wide-angle position, fFT is a combined focal length of the front unit with a

negative refracting power at the telephoto position, fw is the focal length of the objective optical system at the wide-angle position, and fT is the focal length of the objective optical system at the telephoto position.

When Conditions (13) and (14) are satisfied at the same time, the balance between the performance and the back focal distance of the objective optical system can be maintained. If the lower limit of Condition (13) or (14) is passed, a negative combined refracting power of the front unit will be strengthened, and thus the fluctuation of aberration caused by the movement of the second and third units for changing the magnification becomes heavy.

On the other hand, if the upper limit of Condition (13) or (14) is exceeded, the negative combined refracting power of the front unit will be diminished, and hence a long back focal distance caused by the retrofocus arrangement will cease to be completely obtainable.

It is desirable that the real image mode finder optical system of the present invention satisfies the following condition:

$$2.7 < mT / mW < 7.0 \tag{15}$$

where mW is the finder magnification of the entire system at the wide-angle position and mT is the finder magnification of the entire system at the telephoto position.

The present invention provides a preferred zoom ratio in the real image mode finder optical system described above.

Below the lower limit of Condition (15), the performance of the finder optical system cannot be completely exercised. On the other hand, beyond the upper limit of Condition (15), the refracting power of each unit becomes too strong and aberration is liable to occur.

It is favorable that that the photographing apparatus according to the present invention has the photographing optical system and the real image mode finder optical

system which has been described.

Also, in the above description, where the reflecting surface is configured as a roof reflecting surface, it is assumed that the roof reflecting surface is constructed with two reflecting surfaces.

The real image mode finder optical system according to the present invention includes, in order from the object side, an objective optical system which has a positive refracting power and changes the magnification of the finder, a field frame located in the proximity of the imaging position of the objective optical system, and an eyepiece optical system with a positive refracting power. The real image mode finder optical system has an image erecting means, and the objective optical system includes, in order from the object side, a first unit with a negative refracting power, a second unit with a positive refracting power, a third unit with a negative refracting power, and a fourth unit with a positive refracting power. The magnification is changed, ranging from the wide-angle position to the telephoto position, by simply moving the second unit toward the object side and the third unit toward the eyepiece side. A combined focal length of the first, second, and third units is negative, and when the magnification is changed over the range from the wide-angle position to the telephoto position, a combined imaging magnification of the second and third units is 1×.

In this case, it is favorable that the real image mode finder optical system constructed as mentioned above satisfies Condition (10).

Furthermore, in the real image mode finder optical system of the present invention, it is favorable that the second unit is constructed with a single lens and satisfies Condition (11).

As described above, in order to increase the angle of emergence, it is only necessary to increase the size of an image obtained by the objective optical system, that is, the size of the field frame, or to reduce the focal length of the eyepiece optical system.

However, if the field frame is enlarged with respect to the focal length of the eyepiece optical system, the objective optical system must be also enlarged. Moreover, since the burden of correction for aberration to the eyepiece optical system will be increased, it becomes difficult that good performance of the eyepiece optical system and compactness due to a simple arrangement are compatible with each other. Thus, in order to keep the size of the finder compact and increase the angle of emergence, it is desirable to reduce the focal length of the eyepiece optical system.

However, when the focal length of the eyepiece optical system is reduced, the distance on the optical axis between the front principal point of the eyepiece optical system and the field frame is diminished, and, for example, space for arranging the optical elements of the image erecting means is narrowed. Consequently, it is necessary that the back focal distance of the objective optical system is increased to place the image erecting means there.

Thus, in the present invention, the objective optical system is designed to have, in order to the object side, the first unit with a negative refracting power, the second unit with a positive refracting power, the third unit with a negative refracting power, and the fourth unit with a positive refracting power so that the combined focal length of the first, second, and third units is negative.

By doing so, the objective optical system is arranged to be of a retrofocus type, and therefore, the back focal distance of the objective optical system can be increased. Thus, according to the present invention, the focal length of the eyepiece optical system can be reduced, and a real image mode finder optical system which has a large angle of emergence and is compact in design can be achieved.

When the magnification of the finder is changed, it is necessary that a variable magnification function is chiefly imparted to one of at least two moving lens units and a diopter correcting function involved in the magnification change is chiefly imparted

to the other. In this case, the amount of movement of the lens unit having the variable magnification function becomes larger than that of the lens unit having the diopter correcting function, and a mechanism for movement is liable to be complicated and oversized.

Thus, in the present invention, the finder optical system is constructed so that the magnification is changed, ranging from the wide-angle position to the telephoto position, by simply moving the second unit toward the object side and the third unit toward the eyepiece side.

By doing so, both the variable magnification function and the diopter correcting function can be shared between the second unit and the third unit. Hence, the amount of movement of each of the second and third units where the magnification is change can be kept to a minimum, and compactness of the mechanism for movement is obtained.

In order to achieve compactness of the objective optical system, it is only necessary to increase the refracting power of each of the second and third units for changing the magnification. In this case, however, the fluctuation of aberration where the magnification is changed becomes heavy.

Here, in the whole range in which the magnification is changed, if an attempt is made so that the combined imaging magnification of the second and third units becomes lower than 1×, there is a tendency that the refracting power of the third unit is increased. In this case, since the refracting power of the first unit must be diminished, the diameter of the first unit must be increased.

On the other hand, if an attempt is made so that the combined imaging magnification of the second and third units becomes higher than 1×, there is a tendency that the refracting power of the second unit is increased. In this case, since the refracting power of the first unit must be increased, the diopter shift caused by a change of space

between the first and second units becomes particularly considerable.

Thus, if the combined imaging magnification of the second and third units is changed so that it becomes 1×, the balance between the performance and the size of the objective optical system can be optimized.

The second and third units bear the variable magnification function and the diopter correcting function, but if the diopter correction is not completely made, the diopter shift will be produced. In particular, when the angle of emergence is increased, the diopter shift is liable to occur.

When the finder optical system is designed to satisfy Condition (10), a state where the imaging magnification of the second unit is −1× at an object distance of 3 m practically coincides with a state where the imaging magnification of the third unit is −1× at an object distance of 3 m when the magnification is changed over the range from the wide-angle position to the telephoto position. As a result, diopter correction can be favorably made over the whole range in which the magnification is changed.

When the finder optical system is designed to satisfy Condition (11), the fluctuation of performance where the magnification is changed can be suppressed. If the upper or lower limit of Condition (11) is passed, the fluctuation of aberration where the magnification is changed becomes heavy.

In the real image mode finder optical system of the present invention, it is favorable that each of the second and third units is constructed with a single lens and satisfies Condition (12).

Condition (12) defines a condition relative to the refracting powers of the second and third units for suppressing a change in performance where the magnification is changed. Below the lower limit of Condition (12), the refracting power of the third unit is increased, and the fluctuation of aberration where the magnification is changed becomes heavy. Beyond the upper limit of Condition (12), the refracting power of

the second unit is increased, and the fluctuation of aberration where the magnification is changed becomes heavy.

It is favorable that the real image mode finder optical system of the present invention satisfies the following conditions at the same time:

$$-1.0 < fw / fw123 < -0.4 \quad (16)$$

$$-1.0 < fT / fT123 < -0.4 \quad (17)$$

where fw123 is a combined focal length of the first, second, and third units at the wide-angle position and fT123 is a combined focal length of the first, second, and third units at the telephoto position.

When Conditions (16) and (17) are satisfied at the same time, the balance between the performance and the back focal distance of the objective optical system can be maintained. If the lower limit of Condition (16) or (17) is passed, a negative combined refracting power of each of the first, second, and third units will be strengthened, and thus the fluctuation of aberration caused by the movement of the second and third units for changing the magnification becomes heavy.

On the other hand, if the upper limit of Condition (16) or (17) is exceeded, the negative combined refracting power of each of the first, second, and third units will be diminished, and hence a long back focal distance caused by the retrofocus arrangement will cease to be completely obtainable.

It is favorable that the real image mode finder optical system is constructed so that when the magnification is changed over the range from the wide-angle position to the telephoto position, the fourth unit remains fixed.

By doing so, the number of units to be moved can be lessened, and cost can be reduced accordingly.

In the real image mode finder optical system of the present invention, it is favorable that the fourth unit is constructed with two optical units with positive refracting

powers.

In the case where the variable magnification ratio of the finder optical system is increased to particularly extend the variable magnification range to the wide-angle side, a high refracting power is required for the unit with a positive refracting power on the eyepiece side of the third unit. The inclination of the marginal beam with respect to the optical axis where the magnification is changed at the wide-angle position is large immediately after the beam emerges from the third unit. Hence, in order to make this inclined beam parallel in the proximity of the field frame, a great positive refracting power is required on the rear side of the third unit. In this case, it is desirable that the great positive refracting power is shared among a plurality of surfaces because the performance of the objective optical system is improved.

As explained above, when the two optical units with positive refracting powers are arranged on the eyepiece side of the third unit, the lens function can be shared between opposite surfaces of the two optical units with positive refracting powers, and hence the performance of the objective optical system can be improved.

In the real image mode finder optical system of the present invention, it is favorable that the fourth unit has a plurality of reflecting surfaces.

Thus, when at least half of the image erecting function is shared to the objective optical system, an increase in thickness along the optical axis of incidence of the objective optical system can be suppressed and at the same time, the distance between an intermediate image and an eyepiece is reduced. Consequently, a finder which has a large angle of emergence can be obtained.

In the real image mode finder optical system of the present invention, it is favorable that the two optical units are prisms having reflecting surfaces.

When at least half of the image erecting function is shared to the objective optical system, an increase in thickness along the optical axis of incidence of the objective

optical system can be suppressed and at the same time, the distance between an intermediate image and an eyepiece is reduced. Consequently, a finder which has a large angle of emergence can be obtained.

It is favorable that the real image mode finder optical system is constructed so that the magnification is changed, ranging from the wide-angle position to the telephoto position, by moving the first unit as well.

The second and third units bear the variable magnification function and the diopter correcting function, but if the diopter correction is not completely made, the diopter shift will be produced.

Where the units for changing the magnification are constructed with only the second and third units, diopter correction cannot be favorably made over the whole range in which the magnification is changed, unless a state where the imaging magnification of the second unit is $-1\times$ practically coincides with a state where the imaging magnification of the third unit is $-1\times$ when the magnification is changed over the range from the wide-angle position to the telephoto position.

However, when the first unit is also moved to change the magnification, restrictions on imaging magnifications of the second and third units are eliminated, and the performance of the objective optical system can be easily improved.

The real image mode finder optical system of the present invention may be constructed so that when the magnification is changed over the range from the wide-angle position to the telephoto position, the first unit remains fixed.

By doing so, the number of units to be moved can be lessened, and cost can be reduced accordingly.

In this case, it is favorable that the real image mode finder optical system of the present invention satisfies Condition (15).

The present invention provides a preferred zoom ratio in the real image mode

finder optical system described above.

Below the lower limit of Condition (15), the performance of the finder optical system cannot be completely exercised. On the other hand, beyond the upper limit of Condition (15), the refracting power of each unit becomes too strong and aberration is liable to occur.

It is favorable that that the photographing apparatus according to the present invention has the photographing optical system and the real image mode finder optical system which has been described.

Also, in the above description, where the reflecting surface is configured as a roof reflecting surface, it is assumed that the roof reflecting surface is constructed with two reflecting surfaces.

In accordance with the drawings and numerical data, the embodiments of the real image mode finder optical system of the present invention will be explained below.

In any of the embodiments, the real image mode finder optical system includes, in order from the object side, an objective optical system with a positive refracting power, a field frame placed in the proximity of the imaging position of the objective optical system, and an eyepiece optical system with a positive refracting power, and has an image erecting means.

First embodiment

In the real image mode finder optical system of this embodiment, as shown in Figs. 1-3 and 5A-5C, the objective optical system includes, in order from the object side, a first unit G1 with a negative refracting power, a second unit G2 with a positive refracting power, a third unit G3 with a negative refracting power, and a fourth unit G4 with a positive refracting power, and has a positive refracting power as a whole.

The fourth unit G4 is constructed with two prisms P1 and P2. The eyepiece optical system is constructed with a prism P and a positive lens E1 and has a positive

refracting power as a whole. Also, in Fig. 5A, symbol EP represents an eyepoint.

The image erecting means includes the prisms P1 and P2 and the prism P. In the real image mode finder optical system of the first embodiment, an intermediate image formed by the objective optical system is interposed between the prism P2 and the prism P, and the field frame, such as that shown in Fig. 4, is provided in the proximity of its imaging position.

The magnification of the finder is changed in the range from the wide-angle position to the telephoto position by fixing the first unit G1 and the fourth unit G4 and by moving the second unit G2 and the third unit G3 along the optical axis.

Each of the first unit G1, the second unit G2, and the third unit G3 is constructed with a single lens. The entrance surface and the exit surface of the prism P1 and the entrance surface of the prism P2 have finite curvatures. The entrance surface and the exit surface of the prism P also have finite curvatures.

The prisms P1 and P2 and the prism P, as shown in Figs. 1-3, are provided with reflecting surfaces $P1_1$, $P2_1$, $P2_2$, and P_1 along the optical path so that the optical axis is bent to erect an image. Specifically, as shown in Fig. 3, the reflecting surface $P1_1$ provided in the prism P1 bends the optical axis in a Y-Z plane; as shown in Figs. 2 and 3, the two reflecting surfaces $P2_1$ and $P2_2$ provided in the prism P2 bend the optical axis in the Y-Z plane and an X-Z plane in this order from the object side; and as shown in Fig. 2, the reflecting surface P_1 provided in the prism P bends the optical axis in the X-Z plane. In this way, an erect image is obtained. Also, the arrangement of the reflecting surfaces is based on that of a Porro prism. Angles made with the optical axis bent by the reflecting surfaces are such that, for example, the angles of the optical axis bent by the reflecting surfaces $P1_1$ and P_1 of the prism P1 and the prism P are smaller than 90 degrees and the angles of the optical axis bent by the reflecting surfaces $P2_1$ and $P2_2$ of the prism P2 are larger than 90 degrees. The reflecting surfaces

$P1_1$ and P_1 of the prism P1 and the prism P are coated with metal films, such as silver and aluminum. The reflecting surfaces $P2_1$ and $P2_2$ of the prism P2 utilize total reflection.

However, the ways of bending the optical axis through the prisms and the angles of the optical axis bent by the reflecting surfaces are not limited to the above description. For example, the angle of the optical axis bent by the most field-frame-side reflecting surface $P2_2$ of the prism P2 may be made smaller than 90 degrees so that this reflecting surface is coated with a metal film. Moreover, the angle of the optical axis bent by the reflecting surface P_1 of the prism P may also be made larger than 90 degrees so that this reflecting surface utilizes total reflection.

The positive lens E1 is constructed so that diopter adjustment can be made in accordance with an observer's diopter.

Also, aberration characteristics in the first embodiment are shown in Figs. 6A-6D, 7A-7D, and 8A-8D.

Subsequently, numerical data of optical members constituting the real image mode finder optical system according to the first embodiment are shown below. In the numerical data of the first embodiment, m denotes a finder magnification; ω denotes a field angle; f denotes the focal length of the objective optical system; r_1, r_2, ... represent radii of curvature of the surfaces of individual lenses or prisms; d_1, d_2, ... represent thicknesses of individual lenses or prisms or spaces therebetween; n_{d1}, n_{d2}, ... represent refractive indices of individual lenses or prisms; and ν_{d1}, ν_{d2}, ... represent Abbe's numbers of individual lenses or prisms; mh represents the maximum width of the field frame; fe represents the focal length of the eyepiece optical system; f123 represents a combined focal length of the first to third units; m23 represents a combined imaging magnification of the second and third units where an object distance is 3 m; m2 represents an imaging magnification of the second unit at the middle position

where the object distance is 3 m; and m3 represents an imaging magnification of the third unit at the middle position where the object distance is 3 m.

Also, the configuration of the aspherical surface, as already described, is expressed by the following equation:

$$z = (y^2 / r) \;/\; [1 + \sqrt{\{1 - (1 + K)(y / r)^2\}}] + A_4 y^4 + A_6 y^6 + A_8 y^8 + A_{10} y^{10}$$

These symbols are also applied to the embodiments to be described later.

<u>Numerical data 1</u>

	Wide-angle position	Middle position	Telephoto position
m	0.536	1.016	2.075
ω (°)	33.541	17.525	8.746
f (mm)	8.047	15.253	31.147

Pupil dia. (mm) 4.000

$r_1 = 83.6172$

$d_1 = 1.0000$ $\quad n_{d1} = 1.58423$ $\quad \nu_{d1} = 30.49$

$r_2 = 10.0913$ (aspherical)

$d_2 =$ D2 (variable)

$r_3 = 10.3392$ (aspherical)

$d_3 = 4.3149$ $\quad n_{d3} = 1.52542$ $\quad \nu_{d3} = 55.78$

$r_4 = -21.0217$ (aspherical)

$d_4 =$ D2 (variable)

$r_5 = -10.0239$ (aspherical)

$d_5 = 1.0000$ $\quad n_{d5} = 1.58425$ $\quad \nu_{d5} = 30.35$

$r_6 = 10.3239$ (aspherical)

$d_6 =$ D6 (variable)

$r_7 = 11.2869$

$d_7 = 9.9000$ $\quad n_{d7} = 1.52542$ $\quad \nu_{d7} = 55.78$

$r_8 = -23.2085$ (aspherical)

$d_8 = 0.5000$

$r_9 = 15.7633$ (aspherical)

$d_9 = 22.5495$ $n_{d9} = 1.52542$ $\nu_{d9} = 55.78$

$r_{10} = \infty$

$d_{10} = 2.2605$

$r_{11} = \infty$ (field frame)

$d_{11} = 2.5500$

$r_{12} = 15.9503$ (aspherical)

$d_{12} = 15.5600$ $n_{d12} = 1.52542$ $\nu_{d12} = 55.78$

$r_{13} = -38.8890$

$d_{13} = 1.7500$

$r_{14} = 25.2612$

$d_{14} = 5.3200$ $n_{d14} = 1.52542$ $\nu_{d14} = 55.78$

$r_{15} = -16.9795$ (aspherical)

$d_{15} = 17.0491$

$r_{16} = \infty$ (eyepoint)

Aspherical coefficients

Second surface

$K = -1.2950$

$A_4 = 2.10279 \times 10^{-6}$ $A_6 = -2.71836 \times 10^{-7}$ $A_8 = 1.45499 \times 10^{-9}$

Third surface

$K = -0.2610$

$A_4 = -9.12395 \times 10^{-5}$ $A_6 = -3.93632 \times 10^{-7}$ $A_8 = -6.31136 \times 10^{-9}$

Fourth surface

$K = -0.0224$

$A_4 = 8.97235 \times 10^{-5}$ $A_6 = -4.73271 \times 10^{-7}$ $A_8 = -1.37810 \times 10^{-9}$

Fifth surface

$K = 0.2143$

$A_4 = 6.18253 \times 10^{-4}$ $A_6 = -3.45137 \times 10^{-5}$ $A_8 = 7.99836 \times 10^{-7}$

Sixth surface

$K = -0.0423$

$A_4 = 1.66996 \times 10^{-6}$ $A_6 = -2.60860 \times 10^{-5}$ $A_8 = 6.01778 \times 10^{-7}$

Eighth surface

$K = 0.1568$

$A_4 = 2.22420 \times 10^{-4}$ $A_6 = -1.28141 \times 10^{-6}$ $A_8 = 3.95727 \times 10^{-8}$

Ninth surface

$K = 0.0140$

$A_4 = -1.11940 \times 10^{-5}$ $A_6 = -1.42736 \times 10^{-6}$

Twelfth surface

$K = 0.0000$

$A_4 = -1.19998 \times 10^{-3}$ $A_6 = 1.07234 \times 10^{-5}$

Fifteenth surface

$K = 0.0000$

$A_4 = 4.29178 \times 10^{-5}$ $A_6 = 1.34232 \times 10^{-7}$

Zoom data

	Wide-angle position	Middle position	Telephoto position
D2	11.6242	7.1879	3.4246
D4	1.2500	8.2976	16.2705
D6	7.8209	5.2097	1.0000

mh = 10.139 mm

	Wide-angle position	Middle position	Telephoto position

f123	-10.436	-19.857	-41.578
m23	0.529	1.000	2.044
m2		-1.000	
m3		-1.000	

		Wide-angle position	Middle position	Telephoto position
Condition (9)	MG45	-0.773	-0.775	-0.776

Conditions (1), (7)	mh / fe	= 0.676
Conditions (2), (3)	fe	= 15.009 mm
Condition (8)	ϕ(mh / 2)	= -0.377955 (1 / mm)
Condition (10)	β3	= -1.000
Condition (11)	SF2	= -0.341
Condition (12)	f2 / f3	= -1.619
Condition (13)	fw / fFw	= -0.771
Condition (14)	fT / fFT	= -0.749
Condition (15)	mT / mW	= 3.871
Condition (16)	fw / fw123	= -0.771
Condition (17)	fT / fT123	= -0.749

Second embodiment

In the real image mode finder optical system of this embodiment, as shown in Figs. 9A-9C, the objective optical system includes, in order from the object side, the first unit G1 with a negative refracting power, the second unit G2 with a positive refracting power, the third unit G3 with a negative refracting power, and the fourth unit G4 with a positive refracting power, and has a positive refracting power as a whole.

The fourth unit G4 is constructed with a positive lens L and the prism P1. The eyepiece optical system is constructed with a prism P and a positive lens E1 and has a positive refracting power as a whole.

The image erecting means includes the prism P1 and the prism P. In the real image mode finder optical system of the second embodiment, the intermediate image formed by the objective optical system is interposed between the prism P1 and the prism P, and the field frame, such as that shown in Fig. 4, is provided in the proximity of its imaging position.

The magnification of the finder is changed in the range from the wide-angle position to the telephoto position by fixing the fourth unit G4 and by moving the first unit G1, the second unit G2, and the third unit G3 along the optical axis.

Each of the first unit G1, the second unit G2, and the third unit G3 is constructed with a single lens. The entrance surface and the exit surface of the prism P1 have finite curvatures. The entrance surface and the exit surface of the prism P also have finite curvatures.

The prism P1 and the prism P are provided with reflecting surfaces along the optical path so that the optical axis is bent to obtain an erect image. For example, the prism P1 is provided with three reflecting surfaces (for bending the optical axis twice in the Y-Z plane and once in the X-Z plane in this order from the object side) and the prism P is provided with one reflecting surface (for bending the optical axis in the X-Z plane) to erect the image. Also, the arrangement of the reflecting surfaces is based on that of a Porro prism. Angles made with the optical axis bent by the reflecting surfaces are such that, for example, the angle of the optical axis bent by one reflecting surface of the prism P1 is smaller than 90 degrees and the angles of the optical axis bent by the remaining two reflecting surfaces are larger than 90 degrees, while the angle of the optical axis bent by the reflecting surface of the prism P is smaller than 90 degrees. The reflecting surfaces making angles smaller than 90 degrees are coated with metal films, such as silver and aluminum. The reflecting surfaces of angles larger than 90 degrees utilize total reflection. However, the angles of the optical axis

bent by the reflecting surfaces are not limited to the above description. For example, the angle of the optical axis bent by the most field-frame-side reflecting surface of the prism P1 may be made smaller than 90 degrees so that this reflecting surface is coated with a metal film. Moreover, the angle of the optical axis bent by the reflecting surface of the prism P may also be made larger than 90 degrees so that this reflecting surface utilizes total reflection.

The positive lens E1 is constructed so that diopter adjustment can be made in accordance with an observer's diopter.

Also, aberration characteristics in the second embodiment are shown in Figs. 10A-10D, 11A-11D, and 12A-12D.

Subsequently, numerical data of optical members constituting the real image mode finder optical system according to the second embodiment are shown below.

Numerical data 2

	Wide-angle position	Middle position	Telephoto position
m	0.685	1.176	2.016
ω (°)	26.680	15.434	8.985
f (mm)	10.290	17.649	30.256

Pupil dia. (mm) 4.000

$r_1=37.0457$

$d_1=1.0000$ $n_{d1}=1.58423$ $\nu_{d1}=30.49$

$r_2=9.2320$ (aspherical)

$d_2=$ D2 (variable)

$r_3=9.5256$ (aspherical)

$d_3=4.4760$ $n_{d3}=1.49241$ $\nu_{d3}=57.66$

$r_4=-22.0049$

$d_4=$ D4 (variable)

$r_5=-10.2911$

$d_5=0.7000$ $n_{d5}=1.58423$ $\nu_{d5}=30.49$

$r_6=9.8912$ (aspherical)

$d_6=$ D6 (variable)

$r_7=36.5176$

$d_7=3.5263$ $n_{d7}=1.52542$ $\nu_{d7}=55.78$

$r_8=-11.2570$ (aspherical)

$d_8=0.5000$

$r_9=17.5358$

$d_9=29.0967$ $n_{d9}=1.52542$ $\nu_{d9}=55.78$

$r_{10}=-218.6484$

$d_{10}=2.7527$

$r_{11}=\infty$ (field frame)

$d_{11}=2.9177$

$r_{12}=19.1732$ (aspherical)

$d_{12}=17.0445$ $n_{d12}=1.52542$ $\nu_{d12}=55.78$

$r_{13}=-20.5269$

$d_{13}=1.4765$

$r_{14}=39.9369$ (aspherical)

$d_{14}=3.4455$ $n_{d14}=1.52542$ $\nu_{d14}=55.78$

$r_{15}=-20.1555$ (aspherical)

$d_{15}=15.7651$

$r_{16}=\infty$ (eyepoint)

Aspherical coefficients

Second surface

$K=-1.3017$

$A_4=4.40512\times10^{-5}$ $A_6=1.04845\times10^{-6}$ $A_8=-4.86973\times10^{-9}$

Third surface

K $=-0.1847$

$A_4 = -1.74316 \times 10^{-4}$ $A_6 = -2.38197 \times 10^{-7}$ $A_8 = -6.24988 \times 10^{-9}$

Sixth surface

K $=-0.0683$

$A_4 = -4.82178 \times 10^{-4}$ $A_6 = 3.96724 \times 10^{-6}$ $A_8 = -3.64804 \times 10^{-8}$

Eighth surface

K $=0.1808$

$A_4 = 9.81681 \times 10^{-5}$ $A_6 = 8.46115 \times 10^{-7}$ $A_8 = 8.50642 \times 10^{-9}$

Twelfth surface

K $= 0.0000$

$A_4 = -5.68528 \times 10^{-4}$ $A_6 = -1.76882 \times 10^{-7}$

Fourteenth surface

K $= 0.0000$

$A_4 = -5.49243 \times 10^{-5}$ $A_6 = 1.22082 \times 10^{-6}$

Fifteenth surface

K $= 0.0000$

$A_4 = -2.37429 \times 10^{-5}$ $A_6 = 1.03731 \times 10^{-6}$

Zoom data

	Wide-angle position	Middle position	Telephoto position
D2	11.6070	8.0586	4.1006
D4	1.1067	7.0086	13.2454
D6	6.3793	4.0397	1.6737

mh = 9.765 mm

Conditions (1), (7) mh / fe = 0.650

Conditions (2), (3) fe = 15.011 mm

Third embodiment

In the real image mode finder optical system of this embodiment, as shown in Figs. 13A-13C, the objective optical system includes, in order from the object side, the first unit G1 with a negative refracting power, the second unit G2 with a positive refracting power, the third unit G3 with a negative refracting power, and a fourth unit G4 with a positive refracting power, and has a positive refracting power as a whole.

The fourth unit G4 is constructed with two prisms P1 and P2. The eyepiece optical system is constructed with a negative lens L1 and the positive lens E1 and has a positive refracting power as a whole.

The image erecting means includes the prisms P1 and P2. In the real image mode finder optical system of the third embodiment, the intermediate image formed by the objective optical system is interposed between the prism P2 and the negative lens L1, and the field frame, such as that shown in Fig. 4, is placed in the proximity of its imaging position.

The magnification of the finder is changed in the range from the wide-angle position to the telephoto position by fixing the fourth unit G4 and by moving the first unit G1, the second unit G2, and the third unit G3 along the optical axis.

Each of the first unit G1, the second unit G2, and the third unit G3 is constructed with a single lens. The entrance surface and the exit surface of each of the prisms P1 and P2 have finite curvatures.

The prisms P1 and P2 are provided with reflecting surfaces along the optical path so that the optical axis is bent to obtain an erect image. For example, the prism P1 is provided with one reflecting surface (for bending the optical axis in the Y-Z plane) and the prism P2 is provided with three reflecting surfaces (for bending the optical axis once in the Y-Z plane and twice in the X-Z plane in this order from the object side) to erect the image. Also, the arrangement of the reflecting surfaces is based on that of a

Porro prism. Angles made with the optical axis bent by the reflecting surfaces are such that, for example, the angle of the optical axis bent by the reflecting surface of the prism P1 is smaller than 90 degrees, while the angles of the optical axis bent by two reflecting surfaces of the prism P2 are larger than 90 degrees and the angle of the optical axis bent by the remaining one reflecting surface is smaller than 90 degrees. The reflecting surfaces making angles smaller than 90 degrees are coated with metal films, such as silver and aluminum. The reflecting surfaces of angles larger than 90 degrees utilize total reflection. The positive lens E1 is constructed so that diopter adjustment can be made in accordance with an observer's diopter.

Also, aberration characteristics in the third embodiment are shown in Figs. 14A-14D, 15A-15D, and 16A-16D.

Subsequently, numerical data of optical members constituting the real image mode finder optical system according to the third embodiment are shown below.

Numerical data 3

	Wide-angle position	Middle position	Telephoto position
m	0.692	1.181	2.018
ω (°)	26.656	15.374	8.976
f (mm)	10.375	17.709	30.248
Pupil dia. (mm)	4.000		

$r_1 = -37.0118$

$d_1 = 1.6264$ $n_{d1} = 1.58423$ $\nu_{d1} = 30.49$

$r_2 = 15.0266$ (aspherical)

$d_2 =$ D2 (variable)

$r_3 = 13.6624$ (aspherical)

$d_3 = 4.2776$ $n_{d3} = 1.49241$ $\nu_{d3} = 57.66$

$r_4 = -19.7350$

$d_4 =$ D4 (variable)

$r_5 = -23.9768$

$d_5 = 0.6800$ $n_{d5} = 1.58423$ $\nu_{d5} = 30.49$

$r_6 = 15.4052$ (aspherical)

$d_6 =$ D6 (variable)

$r_7 = 64.0979$

$d_7 = 14.4273$ $n_{d7} = 1.52542$ $\nu_{d7} = 55.78$

$r_8 = -16.0524$ (aspherical)

$d_8 = 0.5000$

$r_9 = 46.4363$

$d_9 = 39.5267$ $n_{d9} = 1.52542$ $\nu_{d9} = 55.78$

$r_{10} = -21.0120$

$d_{10} = 3.7943$

$r_{11} = \infty$ (field frame)

$d_{11} = 6.9095$

$r_{12} = -9.9877$ (asphrical)

$d_{12} = 3.6912$ $n_{d12} = 1.58423$ $\nu_{d12} = 30.49$

$r_{13} = -15.7572$

$d_{13} = 0.9421$

$r_{14} = 19.1293$ (aspherical)

$d_{14} = 7.8836$ $n_{d14} = 1.52542$ $\nu_{d14} = 55.78$

$r_{15} = -10.9574$ (aspherical)

$d_{15} = 15.7651$

$r_{16} = \infty$ (eyepoint)

Aspherical coefficients

Second surface

$K = -1.3019$

$A_4 = -1.08535 \times 10^{-4}$ $A_6 = 1.48477 \times 10^{-6}$ $A_8 = -7.37060 \times 10^{-9}$

Third surface

$K = -0.1784$

$A_4 = -1.38562 \times 10^{-4}$ $A_6 = 1.91486 \times 10^{-7}$ $A_8 = -9.59282 \times 10^{-10}$

Sixth surface

$K = -0.0760$

$A_4 = -4.70450 \times 10^{-5}$ $A_6 = -2.11500 \times 10^{-6}$ $A_8 = 3.61544 \times 10^{-8}$

Eighth surface

$K = 0.1930$

$A_4 = 4.06798 \times 10^{-5}$ $A_6 = -8.51164 \times 10^{-8}$ $A_8 = 3.41981 \times 10^{-9}$

Twelfth surface

$K = 0.0000$

$A_4 = -4.97284 \times 10^{-4}$ $A_6 = -5.19125 \times 10^{-6}$

Fourteenth surface

$K = 0.0000$

$A_4 = 1.11128 \times 10^{-4}$ $A_6 = -2.84749 \times 10^{-6}$

Fifteenth surface

$K = 0.0000$

$A_4 = 1.70029 \times 10^{-4}$ $A_6 = -6.56818 \times 10^{-7}$

Zoom data

	Wide-angle position	Middle position	Telephoto position
D2	25.7084	12.8854	7.7602
D4	1.0000	9.0863	19.8650
D6	2.8644	5.0585	1.4948

mh = 9.621 mm

Conditions (1), (7) mh / fe = 0.642

Conditions (2), (3)		fe = 14.990 mm

Fourth embodiment

In the real image mode finder optical system of this embodiment, as shown in Figs. 17A-17C, the objective optical system includes, in order from the object side, the first unit G1 with a negative refracting power, the second unit G2 with a positive refracting power, the third unit G3 with a negative refracting power, and a fourth unit G4 with a positive refracting power, and has a positive refracting power as a whole.

The fourth unit G4 is constructed with two prisms P1 and P2. The eyepiece optical system is constructed with the negative lens L1 and the positive lens E1 and has a positive refracting power as a whole.

The image erecting means includes the prisms P1 and P2. In the real image mode finder optical system of the fourth embodiment, the intermediate image formed by the objective optical system is interposed between the prism P2 and the negative lens L1, and the field frame, such as that shown in Fig. 4, is placed in the proximity of its imaging position.

The magnification of the finder is changed in the range from the wide-angle position to the telephoto position by fixing the fourth unit G4 and by moving the first unit G1, the second unit G2, and the third unit G3 along the optical axis.

Each of the first unit G1, the second unit G2, and the third unit G3 is constructed with a single lens. The entrance surface and the exit surface of each of the prisms P1 and P2 have finite curvatures.

The prisms P1 and P2 are provided with reflecting surfaces along the optical path so that the optical axis is bent to obtain an erect image. For example, the prism P1 is provided with one reflecting surface (for bending the optical axis in the Y-Z plane) and the prism P2 is provided with three reflecting surfaces (for bending the optical axis once in the Y-Z plane and twice in the X-Z plane in this order from the object side) to

erect the image. Also, the arrangement of the reflecting surfaces is based on that of a Porro prism. Angles made with the optical axis bent by the reflecting surfaces are such that, for example, the angle of the optical axis bent by the reflecting surface of the prism P1 is smaller than 90 degrees, while the angles of the optical axis bent by two reflecting surfaces of the prism P2 are larger than 90 degrees and the angle of the optical axis bent by the remaining one reflecting surface is smaller than 90 degrees. The reflecting surfaces making angles smaller than 90 degrees are coated with metal films, such as silver and aluminum. The reflecting surfaces of angles larger than 90 degrees utilize total reflection. The positive lens E1 is constructed so that diopter adjustment can be made in accordance with an observer's diopter.

Also, aberration characteristics in the fourth embodiment are shown in Figs. 18A-18D, 19A-19D, and 20A-20D.

Subsequently, numerical data of optical members constituting the real image mode finder optical system according to the fourth embodiment are shown below.

Numerical data 4

	Wide-angle position	Middle position	Telephoto position
m	0.574	0.980	1.680
ω (°)	26.946	15.541	9.003
f (mm)	8.612	14.706	25.218

Pupil dia. (mm) 4.000

$r_1 = -27.7265$

$d_1 = 0.7033$ $n_{d1} = 1.58423$ $\nu_{d1} = 30.49$

$r_2 = 12.5528$ (aspherical)

$d_2 =$ D2 (variable)

$r_3 = 11.3610$ (aspherical)

$d_3 = 3.8444$ $n_{d3} = 1.49241$ $\nu_{d3} = 57.66$

r_4=-15.8341

d_4= D4 (variable)

r_5=-18.1098

d_5=0.7000 n_{d5}=1.58423 ν_{d5}=30.49

r_6=11.6071 (aspherical)

d_6= D6 (variable)

r_7=53.8289

d_7=12.8726 n_{d7}=1.52542 ν_{d7}=55.78

r_8=-14.5655 (aspherical)

d_8=1.0000

r_9=23.4433

d_9=34.8807 n_{d9}=1.52542 ν_{d9}=55.78

r_{10}=-28.7418

d_{10}=1.4329

$r_{11}=\infty$ (field frame)

d_{11}=6.9526

r_{12}=-12.6182 (aspherical)

d_{12}=3.6221 n_{d12}=1.58423 ν_{d12}=30.49

r_{13}=-15.2579

d_{13}=1.1803

r_{14}=24.0716 (aspherical)

d_{14}=8.3376 n_{d14}=1.52542 ν_{d14}=55.78

r_{15}=-11.3348 (aspherical)

d_{15}=15.7651

$r_{16}=\infty$ (eyepoint)

Aspherical coefficients

Second surface

K $=-1.3022$

$A_4 = -2.00833\times10^{-4}$ $A_6 = 3.41784\times10^{-6}$ $A_8 = -1.63261\times10^{-8}$

Third surface

K $=-0.1825$

$A_4 = -2.54261\times10^{-4}$ $A_6 = 5.60513\times10^{-7}$ $A_8 = -3.79136\times10^{-9}$

Sixth surface

K $=-0.0762$

$A_4 = -1.57743\times10^{-4}$ $A_6 = -3.09431\times10^{-6}$ $A_8 = 4.76542\times10^{-8}$

Eighth surface

K $= 0.1928$

$A_4 = 4.63808\times10^{-5}$ $A_6 = -2.97595\times10^{-7}$ $A_8 = 8.60163\times10^{-9}$

Twelfth surface

K $= 0.0000$

$A_4 = -6.08556\times10^{-4}$ $A_6 = -8.85765\times10^{-6}$

Fourteenth surface

K $= 0.0000$

$A_4 = 1.52011\times10^{-4}$ $A_6 = -1.19503\times10^{-6}$

Fifteenth surface

K $= 0.0000$

$A_4 = 1.06106\times10^{-4}$ $A_6 = 8.55846\times10^{-7}$

Zoom data

	Wide-angle position	Middle position	Telephoto position
D2	21.4497	10.4751	6.4304
D4	1.0000	7.7777	16.8353
D6	1.9906	3.8269	1.3800

mh = 8.107 mm

Conditions (1), (7) mh / fe = 0.540

Conditions (2), (3) fe = 15.010 mm

Fifth embodiment

In the real image mode finder optical system of this embodiment, as shown in Figs. 21A-21C, the objective optical system includes, in order from the object side, the first unit G1 with a negative refracting power, the second unit G2 with a positive refracting power, the third unit G3 with a negative refracting power, and a fourth unit G4 with a positive refracting power, and has a positive refracting power as a whole.

The fourth unit G4 is constructed with two prisms P1 and P2. The eyepiece optical system is constructed with the negative lens L1 and the positive lens E1 and has a positive refracting power as a whole.

The image erecting means includes the prisms P1 and P2. In the real image mode finder optical system of the fifth embodiment, the intermediate image formed by the objective optical system is interposed between the prism P2 and the negative lens L1, and the field frame, such as that shown in Fig. 4, is placed in the proximity of its imaging position.

The magnification of the finder is changed in the range from the wide-angle position to the telephoto position by fixing the fourth unit G4 and by moving the first unit G1, the second unit G2, and the third unit G3 along the optical axis.

Each of the first unit G1, the second unit G2, and the third unit G3 is constructed with a single lens. The entrance surface and the exit surface of each of the prisms P1 and P2 have finite curvatures.

The prisms P1 and P2 are provided with reflecting surfaces along the optical path so that the optical axis is bent to obtain an erect image. For example, the prism P1 is provided with one reflecting surface (for bending the optical axis in the Y-Z plane) and

the prism P2 is provided with three reflecting surfaces (for bending the optical axis once in the Y-Z plane and twice in the X-Z plane in this order from the object side) to erect the image. Also, the arrangement of the reflecting surfaces is based on that of a Porro prism. Angles made with the optical axis bent by the reflecting surfaces are such that, for example, the angle of the optical axis bent by the reflecting surface of the prism P1 is smaller than 90 degrees, while the angles of the optical axis bent by two reflecting surfaces of the prism P2 are larger than 90 degrees and the angle of the optical axis bent by the remaining one reflecting surface is smaller than 90 degrees. The reflecting surfaces making angles smaller than 90 degrees are coated with metal films, such as silver and aluminum. The reflecting surfaces of angles larger than 90 degrees utilize total reflection. The positive lens E1 is constructed so that diopter adjustment can be made in accordance with an observer's diopter.

Also, aberration characteristics in the fifth embodiment are shown in Figs. 22A-22D, 23A-23D, and 24A-24D.

Subsequently, numerical data of optical members constituting the real image mode finder optical system according to the fifth embodiment are shown below.

<u>Numerical data 5</u>

	Wide-angle position	Middle position	Telephoto position
m	0.873	1.293	2.418
ω (°)	24.751	16.220	8.611
f (mm)	13.110	19.409	36.290
Pupil dia. (mm)	4.000		

r_1 = -39.3543

d_1 = 2.0000 n_{d1} = 1.58423 ν_{d1} = 30.49

r_2 = 20.1886 (aspherical)

d_2 = D2 (variable)

$r_3 = 17.8228$ (aspherical)

$d_3 = 4.5550$ $n_{d3} = 1.49241$ $\nu_{d3} = 57.66$

$r_4 = -20.6969$

$d_4 =$ D4 (variable)

$r_5 = -26.5948$

$d_5 = 0.9712$ $n_{d5} = 1.58423$ $\nu_{d5} = 30.49$

$r_6 = 21.3842$ (aspherical)

$d_6 =$ D6 (variable)

$r_7 = 49.7469$

$d_7 = 16.0933$ $n_{d7} = 1.52542$ $\nu_{d7} = 55.78$

$r_8 = -23.8038$ (aspherical)

$d_8 = 0.6446$

$r_9 = 38.3198$

$d_9 = 43.7612$ $n_{d9} = 1.52542$ $\nu_{d9} = 55.78$

$r_{10} = -63.9202$

$d_{10} = 2.7501$

$r_{11} = \infty$ (field frame)

$d_{11} = 7.1509$

$r_{12} = -7.9810$ (aspherical)

$d_{12} = 3.6432$ $n_{d12} = 1.58423$ $\nu_{d12} = 30.49$

$r_{13} = -11.3215$

$d_{13} = 1.2765$

$r_{14} = 16.6904$ (aspherical)

$d_{14} = 7.6344$ $n_{d14} = 1.52542$ $\nu_{d14} = 55.78$

$r_{15} = -13.2210$ (aspherical)

$d_{15} = 15.7651$

$r_{16} = \infty$ (eyepoint)

Aspherical coefficients

Second surface

$K = -1.3021$

$A_4 = -3.80325 \times 10^{-5}$ $A_6 = 5.97449 \times 10^{-7}$ $A_8 = -2.67271 \times 10^{-9}$

Third surface

$K = -0.1774$

$A_4 = -7.61365 \times 10^{-5}$ $A_6 = 1.22273 \times 10^{-7}$ $A_8 = -3.41547 \times 10^{-10}$

Sixth surface

$K = -0.0759$

$A_4 = -3.60399 \times 10^{-5}$ $A_6 = -1.18573 \times 10^{-7}$ $A_8 = 9.28811 \times 10^{-10}$

Eighth surface

$K = 0.1900$

$A_4 = 1.33964 \times 10^{-5}$ $A_6 = 5.39206 \times 10^{-8}$ $A_8 = -9.03386 \times 10^{-11}$

Twelfth surface

$K = 0.0000$

$A_4 = -2.69230 \times 10^{-4}$ $A_6 = -2.03083 \times 10^{-6}$

Fourteenth surface

$K = 0.0000$

$A_4 = 8.14903 \times 10^{-5}$ $A_6 = -1.34641 \times 10^{-6}$

Fifteenth surface

$K = 0.0000$

$A_4 = 1.81061 \times 10^{-4}$ $A_6 = -6.24901 \times 10^{-7}$

Zoom data

	Wide-angle position	Middle position	Telephoto position
D2	29.0804	15.7590	8.2552

D4	1.0000	8.0891	22.1773
D6	3.1755	8.1368	2.0110

mh = 11.006 mm

Conditions (1), (7) mh / fe = 0.733

Conditions (2), (3) fe = 15.010 mm

Sixth embodiment

The arrangement of this embodiment is similar to that of the first embodiment described with reference to Figs. 1-4. Figs. 25A-25D show the arrangement of the sixth embodiment. In this embodiment, low-dispersion glass is used for the positive lens E1 to suppress chromatic aberration of magnification produced in the eyepiece optical system.

Also, aberration characteristics in the sixth embodiment are shown in Figs. 26A-26D, 27A-27D, 28A-28D, and 29A-29D.

Subsequently, numerical data of optical members constituting the real image mode finder optical system according to the sixth embodiment are shown below.

Numerical data 6

	Wide-angle position	Middle position	Telephoto position
m	0.743	1.016	2.072
ω (°)	23.854	17.511	8.739
f (mm)	11.156	15.252	31.104

Pupil dia. (mm) 4.000

$r_1 = 81.9112$

$d_1 = 1.0000$ $n_{d1} = 1.58423$ $\nu_{d1} = 30.49$

$r_2 = 10.0742$ (aspherical)

$d_2 =$ D2 (variable)

$r_3 = 10.3535$ (aspherical)

$d_3 = 4.3238$ $n_{d3} = 1.52542$ $\nu_{d3} = 55.78$

$r_4 = -20.9984$ (aspherical)

$d_4 =$ D4 (variable)

$r_5 = -10.0333$ (aspherical)

$d_5 = 1.0000$ $n_{d5} = 1.58425$ $\nu_{d5} = 30.35$

$r_6 = 10.3333$ (aspherical)

$d_6 =$ D6 (variable)

$r_7 = 11.3130$

$d_7 = 9.9000$ $n_{d7} = 1.52542$ $\nu_{d7} = 55.78$

$r_8 = -23.1581$ (aspherical)

$d_8 = 0.5000$

$r_9 = 15.7417$ (aspherical)

$d_9 = 22.5485$ $n_{d9} = 1.52542$ $\nu_{d9} = 55.78$

$r_{10} = \infty$

$d_{10} = 2.2615$

$r_{11} = \infty$ (field frame)

$d_{11} = 2.5500$

$r_{12} = 15.2310$ (aspherical)

$d_{12} = 15.5600$ $n_{d12} = 1.52542$ $\nu_{d12} = 55.78$

$r_{13} = -39.1300$

$d_{13} = 1.7500$

$r_{14} = 24.5529$

$d_{14} = 5.3200$ $n_{d14} = 1.49700$ $\nu_{d14} = 81.54$

$r_{15} = -15.8669$ (aspherical)

$d_{15} = 17.0491$

$r_{16} = \infty$ (eyepoint)

Aspherical coefficients

Second surface

K $=-1.2950$

$A_4 = 5.82582 \times 10^{-6}$ $A_6 = -2.91852 \times 10^{-7}$ $A_8 = 1.53866 \times 10^{-9}$

Third surface

K $=-0.2618$

$A_4 = -8.99427 \times 10^{-5}$ $A_6 = -3.14079 \times 10^{-7}$ $A_8 = -8.23133 \times 10^{-9}$

Fourth surface

K $=-0.0224$

$A_4 = 8.74333 \times 10^{-5}$ $A_6 = -3.77249 \times 10^{-7}$ $A_8 = -3.31925 \times 10^{-9}$

Fifth surface

K $=0.2138$

$A_4 = 6.11164 \times 10^{-4}$ $A_6 = -3.28266 \times 10^{-5}$ $A_8 = 7.55363 \times 10^{-7}$

Sixth surface

K $=-0.0425$

$A_4 = 2.44411 \times 10^{-5}$ $A_6 = -2.80434 \times 10^{-5}$ $A_8 = 6.70880 \times 10^{-7}$

Eighth surface

K $=0.1564$

$A_4 = 2.36396 \times 10^{-4}$ $A_6 = -1.54507 \times 10^{-6}$ $A_8 = 3.28513 \times 10^{-8}$

Ninth surface

K $=0.0138$

$A_4 = 7.48388 \times 10^{-6}$ $A_6 = -1.90449 \times 10^{-6}$

Twelfth surface

K $=0.0000$

$A_4 = -1.19998 \times 10^{-3}$ $A_6 = 1.07234 \times 10^{-5}$

Fifteenth surface

$K \quad = 0.0000$

$A_4 \quad = 5.20019 \times 10^{-5} \qquad A_6 \quad = 1.50643 \times 10^{-7}$

Zoom data

	Wide-angle position	Middle position	Telephoto position
D2	9.1623	7.1846	3.4243
D4	4.9049	8.2975	16.2619
D6	6.6190	5.2041	1.0000

mh = 10.121 mm

Conditions (1), (7) mh / fe = 0.674

Condition (4) ν = 81.54

Conditions (2), (3) fe = 15.010 mm

Seventh embodiment

In the real image mode finder optical system of this embodiment, as shown in Figs. 30A-30D, the objective optical system includes, in order from the object side, a first unit G1 with a negative refracting power, a second unit G2 with a positive refracting power, a third unit G3 with a negative refracting power, and a fourth unit G4 with a positive refracting power, and has a positive refracting power as a whole.

The fourth unit G4 is constructed with two prisms P1 and P2. The eyepiece optical system is constructed with the prism P and the positive lens E1 and has a positive refracting power as a whole.

The image erecting means includes the prisms P1 and P2 and the prism P. In the real image mode finder optical system of the seventh embodiment, the intermediate image formed by the objective optical system is interposed between the prism P2 and the prism P, and the field frame, such as that shown in Fig. 4, is provided in the proximity of its imaging position.

The magnification of the finder is changed in the range from the wide-angle posi-

tion to the telephoto position by fixing the first unit G1 and the fourth unit G4 and by moving the second unit G2 and the third unit G3 along the optical axis.

Each of the first unit G1, the second unit G2, and the third unit G3 is constructed with a single lens. The entrance surface and the exit surface of the prism P1 and the entrance surface of the prism P2 have finite curvatures, that is, are configured as lens surfaces. The entrance surface and the exit surface of the prism P also have finite curvatures.

The prisms P1 and P2 and the prism P, as in the first embodiment shown in Figs. 1-3, are provided with the reflecting surfaces along the optical path so that the optical axis is bent to erect an image. For example, one reflecting surface provided in the prism P1 bends the optical axis in the Y-Z plane; two reflecting surfaces provided in the prism P2 bend the optical axis in the Y-Z plane and the X-Z plane in this order from the object side; and one reflecting surface provided in the prism P bends the optical axis in the X-Z plane. In this way, an erect image is obtained. Also, the arrangement of the reflecting surfaces is based on that of a Porro prism. Angles made with the optical axis bent by the reflecting surfaces are such that, for example, the angles of the optical axis bent by the reflecting surfaces of the prism P1 and the prism P are smaller than 90 degrees and the angles of the optical axis bent by the two reflecting surfaces of the prism P2 are larger than 90 degrees. The reflecting surfaces of the prism P1 and the prism P are coated with metal films, such as silver and aluminum. The two reflecting surfaces of the prism P2 utilize total reflection.

However, the ways of bending the optical axis through the prisms and the angles of the optical axis bent by the reflecting surfaces are not limited to the above description. For example, the angle of the optical axis bent by the most field-frame-side reflecting surface of the prism P2 may be made smaller than 90 degrees so that this reflecting surface is coated with a metal film. Moreover, the angle of the optical axis

bent by the reflecting surface of the prism P may also be made larger than 90 degrees so that this reflecting surface utilizes total reflection.

The positive lens E1 is constructed so that diopter adjustment can be made in accordance with an observer's diopter.

Also, aberration characteristics in the seventh embodiment are shown in Figs. 31A-31D, 32A-32D, 33A-33D, and 34A-34D.

Subsequently, numerical data of optical members constituting the real image mode finder optical system according to the seventh embodiment are shown below.

Numerical data 7

	Wide-angle position	Middle position	Telephoto position
m	0.743	1.015	2.070
ω (°)	23.875	17.526	8.746
f (mm)	11.146	15.237	31.075
Pupil dia. (mm)	4.000		

$r_1 = 81.9602$

$d_1 = 1.0000$ $n_{d1} = 1.58423$ $\nu_{d1} = 30.49$

$r_2 = 10.0611$ (aspherical)

$d_2 =$ D2 (variable)

$r_3 = 10.3753$ (aspherical)

$d_3 = 4.3253$ $n_{d3} = 1.52542$ $\nu_{d3} = 55.78$

$r_4 = -20.8601$ (aspherical)

$d_4 =$ D4 (variable)

$r_5 = -10.0315$ (aspherical)

$d_5 = 1.0000$ $n_{d5} = 1.58425$ $\nu_{d5} = 30.35$

$r_6 = 10.3315$ (aspherical)

$d_6 =$ D6

$r_7 = 11.2984$

$d_7 = 9.9000 \quad n_{d7} = 1.52542 \quad \nu_{d7} = 55.78$

$r_8 = -23.0708$ (aspherical)

$d_8 = 0.5000$

$r_9 = 15.8095$ (aspherical)

$d_9 = 22.5530 \quad n_{d9} = 1.52542 \quad \nu_{d9} = 55.78$

$r_{10} = \infty$

$d_{10} = 2.2570$

$r_{11} = \infty$ (field frame)

$d_{11} = 2.5500$

$r_{12} = 15.4188$ (aspherical)

$d_{12} = 15.5600 \quad n_{d12} = 1.52542 \quad \nu_{d12} = 55.78$

$r_{13} = -37.3902$

$d_{13} = 1.7500$

$r_{14} = 20.4078$

$d_{14} = 5.3200 \quad n_{d14} = 1.43389 \quad \nu_{d14} = 95.15$

$r_{15} = -14.4726$ (aspherical)

$d_{15} = 17.0491$

$r_{16} = \infty$ (eyepoint)

Aspherical coefficients

Second surface

$K = -1.2949$

$A_4 = 6.66017 \times 10^{-6} \quad A_6 = -2.62591 \times 10^{-7} \quad A_8 = 1.12121 \times 10^{-9}$

Third surface

$K = -0.2625$

$A_4 = -7.97190 \times 10^{-5} \quad A_6 = -6.29748 \times 10^{-7} \quad A_8 = -1.17464 \times 10^{-9}$

Fourth surface

K $=-0.0226$

$A_4 = 9.61346 \times 10^{-5}$ $A_6 = -6.24988 \times 10^{-7}$ $A_8 = -2.63996 \times 10^{-9}$

Fifth surface

K $= 0.2132$

$A_4 = 6.22361 \times 10^{-4}$ $A_6 = -3.35122 \times 10^{-5}$ $A_8 = 7.43683 \times 10^{-7}$

Sixth surface

K $= -0.0427$

$A_4 = 3.84712 \times 10^{-5}$ $A_6 = -2.91300 \times 10^{-5}$ $A_8 = 6.92795 \times 10^{-7}$

Eighth surface

K $= 0.1561$

$A_4 = 2.24263 \times 10^{-4}$ $A_6 = -1.03011 \times 10^{-6}$ $A_8 = 3.32247 \times 10^{-8}$

Ninth surface

K $= 0.0135$

$A_4 = -5.19982 \times 10^{-6}$ $A_6 = -1.46612 \times 10^{-6}$

Twelfth surface

K $= 0.0000$

$A_4 = -1.19998 \times 10^{-3}$ $A_6 = 1.07234 \times 10^{-5}$

Fifteenth surface

K $= 0.0000$

$A_4 = 7.35154 \times 10^{-5}$ $A_6 = 2.26014 \times 10^{-7}$

Zoom data

	Wide-angle position	Middle position	Telephoto position
D2	9.1683	7.1925	3.4339
D4	4.8993	8.2891	16.2507
D6	6.6171	5.2031	1.0000

mh = 10.133 mm

Conditions (1), (7)	mh / fe =	0.675
Condition (4)	ν =	95.15
Conditions (2), (3)	fe =	15.010 mm

Eighth embodiment

In the real image mode finder optical system of this embodiment, as shown in Figs. 35A-35D, the objective optical system includes, in order from the object side, a first unit G1 with a negative refracting power, a second unit G2 with a positive refracting power, a third unit G3 with a negative refracting power, and a fourth unit G4 with a positive refracting power, and has a positive refracting power as a whole.

The fourth unit G4 is constructed with two prisms P1 and P2. The eyepiece optical system is constructed with a cemented lens component CE comprised of a positive lens element CE1 and a negative lens element CE2 and has a positive refracting power as a whole.

The image erecting means includes the prisms P1 and P2 and the prism P. In the real image mode finder optical system of the eighth embodiment, the intermediate image formed by the objective optical system is interposed between the prism P2 and the prism P, and the field frame, such as that shown in Fig. 4, is provided in the proximity of its imaging position.

The magnification of the finder is changed in the range from the wide-angle position to the telephoto position by fixing the first unit G1 and the fourth unit G4 and by moving the second unit G2 and the third unit G3 along the optical axis.

Each of the first unit G1, the second unit G2, and the third unit G3 is constructed with a single lens. The entrance surface and the exit surface of the prism P1 and the entrance surface of the prism P2 have finite curvatures. The entrance surface and the exit surface of the prism P also have finite curvatures.

The prisms P1 and P2 and the prism P are provided with the reflecting surfaces along the optical path so that the optical axis is bent to erect an image. For example, the prism P1 is provided with one reflecting surface (for bending the optical axis in the Y-Z plane), the prism P2 is provided with two reflecting surfaces (for bending the optical axis in the Y-Z plane and the X-Z plane), and the prism P is provided with one reflecting surface (for bending the optical axis in the X-Z plane) to erect the image. Also, the arrangement of the reflecting surfaces is based on that of a Porro prism. Angles made with the optical axis bent by the reflecting surfaces are such that, for example, the angles of the optical axis bent by the reflecting surfaces of the prism P1 and the prism P are smaller than 90 degrees and the angles of the optical axis bent by the two reflecting surfaces of the prism P2 are larger than 90 degrees. The reflecting surfaces of the prism P1 and the prism P are coated with metal films, such as silver and aluminum. The two reflecting surfaces of the prism P2 utilize total reflection.

However, the ways of bending the optical axis through the prisms and the angles of the optical axis bent by the reflecting surfaces are not limited to the above description. For example, the angle of the optical axis bent by the most field-frame-side reflecting surface of the prism P2 may be made smaller than 90 degrees so that this reflecting surface is coated with a metal film. Moreover, the angle of the optical axis bent by the reflecting surface of the prism P may also be made larger than 90 degrees so that this reflecting surface utilizes total reflection.

The cemented lens component CE is constructed so that diopter adjustment can be made in accordance with an observer's diopter.

In the eighth embodiment, the cemented lens component CE including, in order from the object side, the positive lens element and the negative lens element is used to suppress the chromatic aberration of magnification produced in the eyepiece optical system.

Also, aberration characteristics in the eighth embodiment are shown in Figs. 36A-36D, 37A-37D, 38A-38D, and 39A-39D.

Subsequently, numerical data of optical members constituting the real image mode finder optical system according to the eighth embodiment are shown below.

Numerical data 8

	Wide-angle position	Middle position	Telephoto position
m	0.743	1.020	2.076
ω (°)	23.954	17.549	8.727
f (mm)	11.160	15.304	31.158

Pupil dia. (mm) 4.000

r_1=75.9203

d_1=1.0000 n_{d1}=1.58423 ν_{d1}=30.49

r_2=10.0850 (aspherical)

d_2= D2 (variable)

r_3=10.2485 (aspherical)

d_3=4.2776 n_{d3}=1.52542 ν_{d3}=55.78

r_4=-21.9093

d_4= D4 (variable)

r_5=-10.0501 (aspherical)

d_5=1.0000 n_{d5}=1.58425 ν_{d5}=30.35

r_6=10.3501 (aspherical)

d_6= D6 (variable)

r_7=11.5799

d_7=9.9000 n_{d7}=1.52542 ν_{d7}=55.78

r_8=-21.8697 (aspherical)

d_8=0.5000

$r_9 = 15.8360$ (aspherical)

$d_9 = 22.6385$ $n_{d9} = 1.52542$ $\nu_{d9} = 55.78$

$r_{10} = \infty$

$d_{10} = 2.1715$

$r_{11} = \infty$ (field frame)

$d_{11} = 2.5500$

$r_{12} = 18.8734$ (aspherical)

$d_{12} = 15.5600$ $n_{d12} = 1.52542$ $\nu_{d12} = 55.78$

$r_{13} = -20.0934$

$d_{13} = 1.7500$

$r_{14} = 36.0448$

$d_{14} = 5.3393$ $n_{d14} = 1.52542$ $\nu_{d14} = 55.78$

$r_{15} = -13.2074$

$d_{15} = 1.0000$ $n_{d15} = 1.58423$ $\nu_{d15} = 30.49$

$r_{16} = -18.5585$ (aspherical)

$d_{16} = 17.0491$

$r_{17} = \infty$ (eyepoint)

Aspherical coefficients

Second surface

$K = -1.2950$

$A_4 = -2.88906 \times 10^{-5}$ $A_6 = 1.81910 \times 10^{-7}$ $A_8 = -1.52765 \times 10^{-9}$

Third surface

$K = -0.2463$

$A_4 = -1.12182 \times 10^{-4}$ $A_6 = -6.22353 \times 10^{-7}$ $A_8 = 2.82153 \times 10^{-9}$

Fourth surface

$K = -0.0226$

$A_4 = 8.40588 \times 10^{-5}$ $A_6 = -7.72274 \times 10^{-7}$ $A_8 = 6.21797 \times 10^{-9}$

Fifth surface

$K = 0.2122$

$A_4 = 1.04005 \times 10^{-3}$ $A_6 = -6.22976 \times 10^{-5}$ $A_8 = 1.48889 \times 10^{-6}$

Sixth surface

$K = -0.0428$

$A_4 = 4.20510 \times 10^{-4}$ $A_6 = -5.35363 \times 10^{-5}$ $A_8 = 1.24406 \times 10^{-6}$

Eighth surface

$K = 0.1561$

$A_4 = 2.78620 \times 10^{-4}$ $A_6 = -1.75114 \times 10^{-6}$ $A_8 = 1.84964 \times 10^{-8}$

Ninth surface

$K = 0.0138$

$A_4 = 7.75842 \times 10^{-5}$ $A_6 = -2.54066 \times 10^{-6}$

Twelfth surface

$K = 0.0000$

$A_4 = -1.19998 \times 10^{-3}$ $A_6 = 1.07234 \times 10^{-5}$

Sixteenth surface

$K = 0.0000$

$A_4 = 1.54561 \times 10^{-5}$ $A_6 = 6.06156 \times 10^{-8}$

Zoom data

	Wide-angle position	Middle position	Telephoto position
D2	9.1388	7.1293	3.3607
D4	4.9642	8.4021	16.3723
D6	6.6307	5.2010	0.9994

mh = 10.095 mm

Conditions (1), (7) mh / fe = 0.673

Conditions (2), (3) fe = 15.010 mm

Conditions (5), (6) $\nu p - \nu n =$ 25.29

Ninth embodiment

In the real image mode finder optical system of this embodiment, as shown in Figs. 40A-40D, the objective optical system includes, in order from the object side, a first unit G1 with a negative refracting power, a second unit G2 with a positive refracting power, a third unit G3 with a negative refracting power, and a fourth unit G4 with a positive refracting power, and has a positive refracting power as a whole.

The fourth unit G4 is constructed with two prisms P1 and P2. The eyepiece optical system is constructed with the cemented lens component CE comprised of the positive lens element CE1 and the negative lens element CE2 and has a positive refracting power as a whole.

The image erecting means includes the prisms P1 and P2 and the prism P. In the real image mode finder optical system of the ninth embodiment, the intermediate image formed by the objective optical system is interposed between the prism P2 and the prism P, and the field frame, such as that shown in Fig. 4, is provided in the proximity of its imaging position.

The magnification of the finder is changed in the range from the wide-angle position to the telephoto position by fixing the first unit G1 and the fourth unit G4 and by moving the second unit G2 and the third unit G3 along the optical axis.

Each of the first unit G1, the second unit G2, and the third unit G3 is constructed with a single lens. The entrance surface and the exit surface of the prism P1 and the entrance surface of the prism P2 have finite curvatures. The entrance surface and the exit surface of the prism P also have finite curvatures.

The prisms P1 and P2 and the prism P are provided with the reflecting surfaces along the optical path so that the optical axis is bent to erect an image. For example,

the prism P1 is provided with one reflecting surface (for bending the optical axis in the Y-Z plane), the prism P2 is provided with two reflecting surfaces (for bending the optical axis in the Y-Z plane and the X-Z plane), and the prism P is provided with one reflecting surface (for bending the optical axis in the X-Z plane) to erect the image. Also, the arrangement of the reflecting surfaces is based on that of a Porro prism. Angles made with the optical axis bent by the reflecting surfaces are such that, for example, the angles of the optical axis bent by the reflecting surfaces of the prism P1 and the prism P are smaller than 90 degrees and the angles of the optical axis bent by the two reflecting surfaces of the prism P2 are larger than 90 degrees. The reflecting surfaces of the prism P1 and the prism P are coated with metal films, such as silver and aluminum. The two reflecting surfaces of the prism P2 utilize total reflection.

However, the ways of bending the optical axis through the prisms and the angles of the optical axis bent by the reflecting surfaces are not limited to the above description. For example, the angle of the optical axis bent by the most field-frame-side reflecting surface of the prism P2 may be made smaller than 90 degrees so that this reflecting surface is coated with a metal film. Moreover, the angle of the optical axis bent by the reflecting surface of the prism P may also be made larger than 90 degrees so that this reflecting surface utilizes total reflection.

The cemented lens component CE is constructed so that diopter adjustment can be made in accordance with an observer's diopter.

In the ninth embodiment, the cemented lens component CE including, in order from the object side, the positive lens element and the negative lens element is used to suppress the chromatic aberration of magnification produced in the eyepiece optical system.

Also, aberration characteristics in the ninth embodiment are shown in Figs. 41A-41D, 42A-42D, 43A-43D, and 44A-44D.

Subsequently, numerical data of optical members constituting the real image mode finder optical system according to the ninth embodiment are shown below.

<u>Numerical data 9</u>

	Wide-angle position	Middle position	Telephoto position
m	0.745	1.019	2.078
ω (°)	23.864	17.523	8.748
f (mm)	11.179	15.288	31.185

Pupil dia. (mm) 4.000

$r_1 = 83.1968$

$d_1 = 1.0000$ $n_{d1} = 1.58423$ $\nu_{d1} = 30.49$

$r_2 = 10.0574$ (aspherical)

$d_2 =$ D2 (variable)

$r_3 = 10.4051$ (aspherical)

$d_3 = 4.3247$ $n_{d3} = 1.52542$ $\nu_{d3} = 55.78$

$r_4 = -20.6708$ (aspherical)

$d_4 =$ D4 (variable)

$r_5 = -10.0283$ (aspherical)

$d_5 = 1.0000$ $n_{d5} = 1.58425$ $\nu_{d5} = 30.35$

$r_6 = 10.3283$ (aspherical)

$d_6 =$ D6 (variable)

$r_7 = 11.0837$

$d_7 = 9.9000$ $n_{d7} = 1.52542$ $\nu_{d7} = 55.78$

$r_8 = -23.2992$ (aspherical)

$d_8 = 0.5000$

$r_9 = 16.1348$ (aspherical)

$d_9 = 22.5851$ $n_{d9} = 1.52542$ $\nu_{d9} = 55.78$

$r_{10} = \infty$

$d_{10} = 2.2249$

$r_{11} = \infty$ (field frame)

$d_{11} = 2.5500$

$r_{12} = 15.1194$ (aspherical)

$d_{12} = 15.5600$ $n_{d12} = 1.52542$ $\nu_{d12} = 55.78$

$r_{13} = -32.9857$

$d_{13} = 1.7500$

$r_{14} = 22.3114$

$d_{14} = 1.0000$ $n_{d14} = 1.58423$ $\nu_{d14} = 30.49$

$r_{15} = 13.0456$

$d_{15} = 5.4129$ $n_{d15} = 1.52542$ $\nu_{d15} = 55.78$

$r_{16} = -18.6581$ (aspherical)

$d_{16} = 17.0491$

$r_{17} = \infty$ (eyepiece)

Aspherical coefficients

Second surface

$K = -1.2945$

$A_4 = 9.89743 \times 10^{-6}$ $A_6 = -4.30715 \times 10^{-7}$ $A_8 = 2.58833 \times 10^{-9}$

Third surface

$K = -0.2627$

$A_4 = -6.69210 \times 10^{-5}$ $A_6 = -9.19006 \times 10^{-7}$ $A_8 = 6.64337 \times 10^{-10}$

Fourth surface

$K = -0.0228$

$A_4 = 1.06273 \times 10^{-4}$ $A_6 = -8.28362 \times 10^{-7}$ $A_8 = 3.85729 \times 10^{-9}$

Fifth surface

$K = 0.2133$

$A_4 = 6.06366 \times 10^{-4}$ $A_6 = -2.97302 \times 10^{-5}$ $A_8 = 5.98935 \times 10^{-7}$

Sixth surface

$K = -0.0427$

$A_4 = 4.82034 \times 10^{-5}$ $A_6 = -2.89969 \times 10^{-5}$ $A_8 = 6.72146 \times 10^{-7}$

Eighth surface

$K = 0.1560$

$A_4 = 2.50445 \times 10^{-4}$ $A_6 = -1.47471 \times 10^{-6}$ $A_8 = 4.11057 \times 10^{-8}$

Ninth surface

$K = 0.0136$

$A_4 = 5.39717 \times 10^{-6}$ $A_6 = -1.68771 \times 10^{-6}$

Twelfth surface

$K = 0.0000$

$A_4 = -1.19998 \times 10^{-3}$ $A_6 = 1.07234 \times 10^{-5}$

Sixteenth surface

$K = 0.0000$

$A_4 = 3.44659 \times 10^{-5}$ $A_6 = 1.08095 \times 10^{-7}$

Zoom data

	Wide-angle position	Middle position	Telephoto position
D2	9.1868	7.2088	3.4518
D4	4.8856	8.2783	16.2383
D6	6.6129	5.1982	0.9952

mh = 10.217 mm

Conditions (1), (7) mh / fe = 0.681

Conditions (2), (3) fe = 15.006 mm

Conditions (5), (6) $\nu p - \nu n$ = 25.29

Tenth embodiment

In the real image mode finder optical system of this embodiment, as shown in Figs. 45A-45D, the objective optical system includes, in order from the object side, the first unit G1 with a negative refracting power, the second unit G2 with a positive refracting power, the third unit G3 with a negative refracting power, and a fourth unit G4 with a positive refracting power, and has a positive refracting power as a whole.

The fourth unit G4 is constructed with two prisms P1 and P2. The eyepiece optical system is constructed with the negative lens L1 and the positive lens E1 and has a positive refracting power as a whole.

The image erecting means includes the prisms P1 and P2. In the real image mode finder optical system of the tenth embodiment, the intermediate image formed by the objective optical system is interposed between the prism P2 and the negative lens L1, and the field frame, such as that shown in Fig. 4, is placed in the proximity of its imaging position.

The magnification of the finder is changed in the range from the wide-angle position to the telephoto position by fixing the fourth unit G4 and by moving the first unit G1, the second unit G2, and the third unit G3 along the optical axis.

Each of the first unit G1, the second unit G2, and the third unit G3 is constructed with a single lens. The entrance surface and the exit surface of each of the prisms P1 and P2 have finite curvatures.

The prisms P1 and P2 are provided with reflecting surfaces along the optical path so that the optical axis is bent to obtain an erect image. For example, the prism P1 is provided with one reflecting surface (for bending the optical axis in the Y-Z plane) and the prism P2 is provided with three reflecting surfaces (for bending the optical axis once in the Y-Z plane and twice in the X-Z plane in this order from the object side) to erect the image. Also, the arrangement of the reflecting surfaces is based on that of a

Porro prism. Angles made with the optical axis bent by the reflecting surfaces are such that, for example, the angle of the optical axis bent by the reflecting surface of the prism P1 is smaller than 90 degrees, while the angles of the optical axis bent by two reflecting surfaces of the prism P2 are larger than 90 degrees and the angle of the optical axis bent by the remaining one reflecting surface is smaller than 90 degrees. The reflecting surfaces making angles smaller than 90 degrees are coated with metal films, such as silver and aluminum. The reflecting surfaces of angles larger than 90 degrees utilize total reflection. The positive lens E1 is constructed so that diopter adjustment can be made in accordance with an observer's diopter.

In the tenth embodiment, low-dispersion glass is used for the positive lens E1 to suppress chromatic aberration of magnification produced in the eyepiece optical system.

Also, aberration characteristics in the tenth embodiment are shown in Figs. 46A-46D, 47A-47D, 48A-48D, and 49A-49D.

Subsequently, numerical data of optical members constituting the real image mode finder optical system according to the tenth embodiment are shown below.

Numerical data 10

	Wide-angle position	Middle position	Telephoto position
m	0.686	1.177	2.019
ω (°)	26.700	15.294	8.889
f (mm)	10.290	17.650	30.261
Pupil dia. (mm)	4.000		

$r_1 = -35.4073$

$d_1 = 1.3547$ $n_{d1} = 1.58423$ $\nu_{d1} = 30.49$

$r_2 = 15.7324$ (aspherical)

$d_2 =$ D2 (variable)

$r_3 = 14.1173$ (aspherical)

$d_3 = 4.2036$ $n_{d3} = 1.49241$ $\nu_{d3} = 57.66$

$r_4 = -19.7136$

$d_4 =$ D4 (variable)

$r_5 = -21.3268$

$d_5 = 1.0000$ $n_{d5} = 1.58423$ $\nu_{d5} = 30.49$

$r_6 = 15.4585$ (aspherical)

$d_6 =$ D6 (variable)

$r_7 = 47.9547$

$d_7 = 14.7087$ $n_{d7} = 1.52542$ $\nu_{d7} = 55.78$

$r_8 = -16.9222$ (aspherical)

$d_8 = 0.5000$

$r_9 = 40.5011$

$d_9 = 39.7256$ $n_{d9} = 1.52542$ $\nu_{d9} = 55.78$

$r_{10} = -22.4670$

$d_{10} = 4.0295$

$r_{11} = \infty$ (field frame)

$d_{11} = 7.6484$

$r_{12} = -6.8411$ (aspherical)

$d_{12} = 3.0616$ $n_{d12} = 1.58423$ $\nu_{d12} = 30.49$

$r_{13} = -9.5101$

$d_{13} = 1.9354$

$r_{14} = 16.4813$

$d_{14} = 5.2395$ $n_{d14} = 1.49700$ $\nu_{d14} = 81.54$

$r_{15} = -12.4181$ (aspherical)

$d_{15} = 15.7651$

$r_{16} = \infty$ (eyepoint)

Aspherical coefficients

Second surface

$K = -1.3019$

$A_4 = -1.03082 \times 10^{-4}$ $A_6 = 1.18309 \times 10^{-6}$ $A_8 = -3.69689 \times 10^{-9}$

Third surface

$K = -0.1784$

$A_4 = -1.31901 \times 10^{-4}$ $A_6 = 1.62576 \times 10^{-7}$ $A_8 = -5.25998 \times 10^{-10}$

Sixth surface

$K = -0.0760$

$A_4 = -7.29856 \times 10^{-5}$ $A_6 = -1.57784 \times 10^{-6}$ $A_8 = 2.85950 \times 10^{-8}$

Eighth surface

$K = 0.1940$

$A_4 = 3.47928 \times 10^{-5}$ $A_6 = 5.46298 \times 10^{-8}$ $A_8 = 1.40140 \times 10^{-9}$

Twelfth surface

$K = 0.0000$

$A_4 = -2.29965 \times 10^{-4}$ $A_6 = -5.49255 \times 10^{-6}$

Fifteenth surface

$K = 0.0000$

$A_4 = 1.23613 \times 10^{-4}$ $A_6 = 7.32239 \times 10^{-7}$

Zoom data

	Wide-angle position	Middle position	Telephoto position
D2	25.8585	12.8666	7.9000
D4	1.0000	9.3310	20.3050
D6	3.2733	5.0026	1.7063

mh = 9.539 mm

Conditions (1), (7) mh / fe = 0.636

Condition (4) ν = 81.54

Conditions (2), (3) fe = 14.990 mm

Eleventh embodiment

In the real image mode finder optical system of this embodiment, as shown in Figs. 50A-50D, the objective optical system includes, in order from the object side, the first unit G1 with a negative refracting power, the second unit G2 with a positive refracting power, the third unit G3 with a negative refracting power, and a fourth unit G4 with a positive refracting power, and has a positive refracting power as a whole.

The fourth unit G4 is constructed with two prisms P1 and P2. The eyepiece optical system is constructed with the negative lens L1 and the cemented lens component CE comprised of the negative lens element CE 2 and the positive lens element CE1, and has a positive refracting power as a whole.

The image erecting means includes the prisms P1 and P2. In the real image mode finder optical system of the eleventh embodiment, the intermediate image formed by the objective optical system is interposed between the prism P2 and the negative lens L1, and the field frame, such as that shown in Fig. 4, is placed in the proximity of its imaging position.

The magnification of the finder is changed in the range from the wide-angle position to the telephoto position by fixing the fourth unit G4 and by moving the first unit G1, the second unit G2, and the third unit G3 along the optical axis.

Each of the first unit G1, the second unit G2, and the third unit G3 is constructed with a single lens. The entrance surface and the exit surface of each of the prisms P1 and P2 have finite curvatures.

The prisms P1 and P2 are provided with reflecting surfaces along the optical path

so that the optical axis is bent to obtain an erect image. For example, the prism P1 is provided with one reflecting surface (for bending the optical axis in the Y-Z plane) and the prism P2 is provided with three reflecting surfaces (for bending the optical axis once in the Y-Z plane and twice in the X-Z plane in this order from the object side) to erect the image. Also, the arrangement of the reflecting surfaces is based on that of a Porro prism. Angles made with the optical axis bent by the reflecting surfaces are such that, for example, the angle of the optical axis bent by the reflecting surface of the prism P1 is smaller than 90 degrees, while the angles of the optical axis bent by two reflecting surfaces of the prism P2 are larger than 90 degrees and the angle of the optical axis bent by the remaining one reflecting surface is smaller than 90 degrees. The reflecting surfaces making angles smaller than 90 degrees are coated with metal films, such as silver and aluminum. The reflecting surfaces of angles larger than 90 degrees utilize total reflection. The cemented lens component CE is constructed so that diopter adjustment can be made in accordance with an observer's diopter.

In the eleventh embodiment, the cemented lens component CE including, in order from the object side, the negative lens element and the positive lens element is used to suppress the chromatic aberration of magnification produced in the eyepiece optical system.

Also, aberration characteristics in the eleventh embodiment are shown in Figs. 51A-51D, 52A-52D, 53A-53D, and 54-54D.

Subsequently, numerical data of optical members constituting the real image mode finder optical system according to the eleventh embodiment are shown below.

<u>Numerical data 11</u>

	Wide-angle position	Middle position	Telephoto position
m	0.685	1.175	2.016
ω (°)	26.509	15.216	8.803

f (mm) 10.289 17.629 30.259

Pupil dia. (mm) 4.000

$r_1 = -31.2936$

$d_1 = 1.3442$ $n_{d1} = 1.58423$ $\nu_{d1} = 30.49$

$r_2 = 16.8814$ (aspherical)

$d_2 =$ D2 (variable)

$r_3 = 14.1167$ (aspherical)

$d_3 = 4.5120$ $n_{d3} = 1.49241$ $\nu_{d3} = 57.66$

$r_4 = -20.4840$

$d_4 =$ D4 (variable)

$r_5 = -20.2406$

$d_5 = 0.9963$ $n_{d5} = 1.58423$ $\nu_{d5} = 30.49$

$r_6 = 14.9676$ (aspherical)

$d_6 =$ D6 (variable)

$r_7 = 41.4899$

$d_7 = 14.6927$ $n_{d7} = 1.52542$ $\nu_{d7} = 55.78$

$r_8 = -17.9428$ (aspherical)

$d_8 = 0.5000$

$r_9 = 34.5533$

$d_9 = 39.7402$ $n_{d9} = 1.52542$ $\nu_{d9} = 55.78$

$r_{10} = -28.4392$

$d_{10} = 4.5510$

$r_{11} = \infty$ (field frame)

$d_{11} = 7.9719$

$r_{12} = -9.6322$ (aspherical)

$d_{12} = 3.1829$ $n_{d12} = 1.58423$ $\nu_{d12} = 30.49$

r_{13}=-10.6815

d_{13}=1.6105

r_{14}=19.4893

d_{14}=1.0000 n_{d14}=1.58423 ν_{d14}=30.49

r_{15}=13.6490

d_{15}=5.4672 n_{d15}=1.49241 ν_{d15}=57.66

r_{16}=-12.4053 (aspherical)

d_{16}=15.7651

r_{17}=∞ (eyepoint)

Aspherical coefficients

Second surface

K =-1.3018

A_4 $=-1.08269\times10^{-4}$ A_6 $=9.30175\times10^{-7}$ A_8 $=-1.42679\times10^{-9}$

Third surface

K =-0.1791

A_4 $=-1.31719\times10^{-4}$ A_6 $=1.67274\times10^{-7}$ A_8 $=-6.28754\times10^{-10}$

Sixth surface

K =-0.0761

A_4 $=-1.10385\times10^{-4}$ A_6 $=-3.75495\times10^{-7}$ A_8 $=2.90075\times10^{-9}$

Eighth surface

K =0.1945

A_4 $=3.40022\times10^{-5}$ A_6 $=-8.32444\times10^{-8}$ A_8 $=2.90545\times10^{-9}$

Twelfth surface

K = 0.0000

A_4 $=-2.80853\times10^{-4}$ A_6 $=-6.97108\times10^{-6}$

Sixteenth surface

$K \quad = 0.0000$

$A_4 \quad = 3.07353 \times 10^{-5} \qquad A_6 \quad = 9.18614 \times 10^{-7}$

Zoom data

	Wide-angle position	Middle position	Telephoto position
D2	25.8073	13.2103	8.2556
D4	0.9957	9.3832	20.5408
D6	3.5101	4.5817	1.6440

mh = 9.486 mm

Conditions (1), (7) mh / fe = 0.632

Conditions (2), (3) fe = 15.010 mm

Conditions (5), (6) νp − νn = 27.17

Twelfth embodiment

The real image mode finder optical system of this embodiment, as shown in Figs. 55A-55C, has nearly the same arrangement as that of the first embodiment with the exception of lens data.

Subsequently, numerical data of optical members constituting the real image mode finder optical system according to the twelfth embodiment are shown below.

Numerical data 12

	Wide-angle position	Middle position	Telephoto position
m	0.530	1.007	2.050
ω (°)	33.694	17.618	8.796
f (mm)	8.482	16.100	32.782

Pupil dia. (mm) 4.000

$r_1 = 52.6894$

$d_1 = 1.0000 \qquad n_{d1} = 1.58423 \qquad \nu_{d1} = 30.49$

$r_2 = 9.9227$ (aspherical)

$d_2 =$ D2 (variable)

$r_3 = 10.2741$ (aspherical)

$d_3 = 4.2589$ $n_{d3} = 1.52542$ $\nu_{d3} = 55.78$

$r_4 = -23.8681$ (aspherical)

$d_4 =$ D4 (variable)

$r_5 = -10.3480$ (aspherical)

$d_5 = 1.0000$ $n_{d5} = 1.58425$ $\nu_{d5} = 30.35$

$r_6 = 10.6480$ (aspherical)

$d_6 =$ D6 (variable)

$r_7 = 11.1372$

$d_7 = 9.9000$ $n_{d7} = 1.52542$ $\nu_{d7} = 55.78$

$r_8 = -26.1339$ (aspherical)

$d_8 = 0.5000$

$r_9 = 15.5869$ (aspherical)

$d_9 = 22.3572$ $n_{d9} = 1.52542$ $\nu_{d9} = 55.78$

$r_{10} = \infty$

$d_{10} = 2.4528$

$r_{11} = \infty$ (field frame)

$d_{11} = 3.0665$

$r_{12} = 15.8132$ (aspherical)

$d_{12} = 15.9408$ $n_{d12} = 1.52542$ $\nu_{d12} = 55.78$

$r_{13} = -75.7570$

$d_{13} = 2.0915$

$r_{14} = 27.2996$

$d_{14} = 4.8098$ $n_{d14} = 1.52542$ $\nu_{d14} = 55.78$

$r_{15} = -16.0615$ (aspherical)

$d_{15} = 16.8220$

$r_{16} = \infty$ (eyepoint)

Aspherical coefficients

Second surface

$K = -1.2951$

$A_4 = 2.66909 \times 10^{-5}$ $A_6 = -2.25605 \times 10^{-7}$ $A_8 = 9.99104 \times 10^{-11}$

Third surface

$K = -0.2614$

$A_4 = -8.86459 \times 10^{-5}$ $A_6 = -2.02523 \times 10^{-7}$ $A_8 = -5.25729 \times 10^{-9}$

Fourth surface

$K = -0.0224$

$A_4 = 6.51575 \times 10^{-5}$ $A_6 = -1.53327 \times 10^{-7}$ $A_8 = -1.18392 \times 10^{-9}$

Fifth surface

$K = 0.2138$

$A_4 = 4.33241 \times 10^{-4}$ $A_6 = -1.93785 \times 10^{-5}$ $A_8 = 4.02985 \times 10^{-7}$

Sixth surface

$K = -0.0427$

$A_4 = -9.91769 \times 10^{-5}$ $A_6 = -1.51811 \times 10^{-5}$ $A_8 = 3.40669 \times 10^{-7}$

Eighth surface

$K = 0.1565$

$A_4 = 2.28575 \times 10^{-4}$ $A_6 = -1.22359 \times 10^{-7}$ $A_8 = 3.27751 \times 10^{-8}$

Ninth surface

$K = 0.0140$

$A_4 = 4.56644 \times 10^{-6}$ $A_6 = -9.81069 \times 10^{-7}$

Twelfth surface

$K = 0.0000$

$A_4 = -7.24335 \times 10^{-4}$ $A_6 = 3.64409 \times 10^{-6}$

Fifteenth surface

$K = 0.0000$

$A_4 = 4.99493 \times 10^{-5}$ $A_6 = 9.74998 \times 10^{-8}$

Zoom data

	Wide-angle position	Middle position	Telephoto position
D2	11.4582	6.8773	3.0038
D4	1.2808	8.5674	16.7674
D6	8.0121	5.3064	0.9799

mh = 10.692 mm

	Wide-angle position	Middle position	Telephoto position
f123	-11.144	-21.243	-44.469
m23	0.529	1.000	2.038
m2		-1.000	
m3		-1.000	

		Wide-angle position	Middle position	Telephoto position
Condition (9)	MG45	-0.763	-0.765	-0.767

Conditions (1), (7) mh / fe = 0.669

Conditions (2), (3) fe = 15.991 mm

Condition (8) ϕ(mh / 2) = -0.406970 (1 / mm)

Condition (10) $\beta 3$ = -1.000

Condition (11) SF2 = -0.389

Condition (12) f2 / f3 = -1.618

Condition (13) fw / fFw = -0.761

Condition (14) fT / fFT = -0.737

Condition (15) mT / mW = 3.865

Condition (16) fw / fw123 = -0.761

Condition (17) $fT / fT123 = -0.737$

Thirteenth embodiment

The real image mode finder optical system of this embodiment, as shown in Figs. 56A-56C, has nearly the same arrangement as that of the first embodiment with the exception of lens data.

Subsequently, numerical data of optical members constituting the real image mode finder optical system according to the thirteenth embodiment are shown below.

Numerical data 13

	Wide-angle position	Middle position	Telephoto position
m	0.533	1.007	2.050
ω (°)	33.897	17.661	8.803
f (mm)	7.468	14.111	28.722

Pupil dia. (mm) 4.000

$r_1 = 166.7316$

$d_1 = 1.0000$ $n_{d1} = 1.58423$ $\nu_{d1} = 30.49$

$r_2 = 10.3218$ (aspherical)

$d_2 =$ D2 (variable)

$r_3 = 10.2841$ (aspherical)

$d_3 = 4.3636$ $n_{d3} = 1.52542$ $\nu_{d3} = 55.78$

$r_4 = -19.9166$ (aspherical)

$d_4 =$ D4 (variable)

$r_5 = -9.8214$ (aspherical)

$d_5 = 1.0000$ $n_{d5} = 1.58425$ $\nu_{d5} = 30.35$

$r_6 = 10.1214$ (aspherical)

$d_6 =$ D6 (variable)

$r_7 = 13.2873$

$d_7 = 9.9000$ $n_{d7} = 1.52542$ $\nu_{d7} = 55.78$

$r_8 = -17.5762$ (aspherical)

$d_8 = 0.5000$

$r_9 = 15.4406$ (aspherical)

$d_9 = 22.6932$ $n_{d9} = 1.52542$ $\nu_{d9} = 55.78$

$r_{10} = \infty$

$d_{10} = 2.1168$

$r_{11} = \infty$ (field frame)

$d_{11} = 2.4325$

$r_{12} = 28.5591$ (aspherical)

$d_{12} = 14.7924$ $n_{d12} = 1.52542$ $\nu_{d12} = 55.78$

$r_{13} = -24.5754$

$d_{13} = 1.2620$

$r_{14} = 27.5003$

$d_{14} = 4.1395$ $n_{d14} = 1.52542$ $\nu_{d14} = 55.78$

$r_{15} = -16.2956$ (aspherical)

$d_{15} = 16.6524$

$r_{16} = \infty$ (eyepoint)

Aspherical coefficients

Second surface

$K = -1.2951$

$A_4 = -9.85470 \times 10^{-6}$ $A_6 = -3.31289 \times 10^{-7}$ $A_8 = 3.00060 \times 10^{-9}$

Third surface

$K = -0.2607$

$A_4 = -9.27092 \times 10^{-5}$ $A_6 = -8.01222 \times 10^{-7}$ $A_8 = 2.80942 \times 10^{-9}$

Fourth surface

$K = -0.0224$

$A_4 = 1.02300 \times 10^{-4}$ $A_6 = -7.73167 \times 10^{-7}$ $A_8 = 5.82839 \times 10^{-9}$

Fifth surface

$K = 0.2137$

$A_4 = 5.86855 \times 10^{-4}$ $A_6 = -2.95943 \times 10^{-5}$ $A_8 = 6.45936 \times 10^{-7}$

Sixth surface

$K = -0.0425$

$A_4 = -2.30372 \times 10^{-5}$ $A_6 = -2.55725 \times 10^{-5}$ $A_8 = 6.22366 \times 10^{-7}$

Eighth surface

$K = 0.1564$

$A_4 = 1.56106 \times 10^{-4}$ $A_6 = -7.63871 \times 10^{-8}$ $A_8 = 4.09536 \times 10^{-9}$

Ninth surface

$K = 0.0137$

$A_4 = 9.52536 \times 10^{-7}$ $A_6 = -1.05084 \times 10^{-6}$

Twelfth surface

$K = 0.0000$

$A_4 = -1.23450 \times 10^{-3}$ $A_6 = 1.00000 \times 10^{-5}$

Fifteenth surface

$K = 0.0000$

$A_4 = 3.90391 \times 10^{-5}$ $A_6 = 1.54761 \times 10^{-7}$

Zoom data

	Wide-angle position	Middle position	Telephoto position
D2	11.7540	7.4253	3.7541
D4	1.2500	8.1247	15.8923
D6	7.6424	5.0964	1.0000

mh = 9.279 mm

	Wide-angle position	Middle position	Telephoto position
f123	-10.011	-18.982	-39.511
m23	0.531	1.000	2.036
m2		-1.000	
m3		-1.000	

		Wide-angle position	Middle position	Telephoto position
Condition (9)	MG45	-0.748	-0.749	-0.751
Conditions (1), (7)	mh / fe	= 0.662		
Conditions (2), (3)	fe	= 14.010 mm		
Condition (8)	$\phi(mh / 2)$	= -0.395473 (1 / mm)		
Condition (10)	$\beta 3$	= -1.000		
Condition (11)	SF2	= -0.319		
Condition (12)	f2 / f3	= -1.622		
Condition (13)	fw / fFw	= -0.746		
Condition (14)	fT / fFT	= -0.727		
Condition (15)	mT / mW	= 3.846		
Condition (16)	fw / fw123	= -0.746		
Condition (17)	fT / fT123	= -0.727		

Fourteenth embodiment

The real image mode finder optical system of this embodiment, as shown in Figs. 57A-57C, has nearly the same arrangement as that of the first embodiment with the exception of lens data.

Subsequently, numerical data of optical members constituting the real image mode finder optical system according to the fourteenth embodiment are shown below.

Numerical data 14

Wide-angle position	Middle position	Telephoto position

m	0.530	1.011	2.054
ω (°)	33.791	17.591	8.810
f (mm)	7.962	15.170	30.830

Pupil dia. (mm) 4.000

$r_1 = 82.9717$

$d_1 = 1.0000$ $n_{d1} = 1.58425$ $\nu_{d1} = 30.35$

$r_2 = 10.0913$ (aspherical)

$d_2 =$ D2 (variable)

$r_3 = 10.3969$ (aspherical)

$d_3 = 4.2911$ $n_{d3} = 1.52542$ $\nu_{d3} = 55.78$

$r_4 = -21.6082$ (aspherical)

$d_4 =$ D4 (variable)

$r_5 = -11.4300$

$d_5 = 1.0000$ $n_{d5} = 1.58425$ $\nu_{d5} = 30.35$

$r_6 = 9.3984$ (aspherical)

$d_6 =$ D6 (variable)

$r_7 = 11.1076$

$d_7 = 9.9000$ $n_{d7} = 1.52542$ $\nu_{d7} = 55.78$

$r_8 = -24.3057$ (aspherical)

$d_8 = 0.5000$

$r_9 = 15.7603$ (aspherical)

$d_9 = 22.4265$ $n_{d9} = 1.52542$ $\nu_{d9} = 55.78$

$r_{10} = \infty$

$d_{10} = 2.2691$

$r_{11} = \infty$ (field frame)

$d_{11} = 2.5500$

$r_{12}=15.9134$ (aspherical)

$d_{12}=15.5881$ $n_{d12}=1.52542$ $\nu_{d12}=55.78$

$r_{13}=-39.1000$

$d_{13}=1.7582$

$r_{14}=25.7997$ (aspherical)

$d_{14}=5.1865$ $n_{d14}=1.52542$ $\nu_{d14}=55.78$

$r_{15}=-16.7689$ (aspherical)

$d_{15}=16.8782$

$r_{16}=\infty$ (eyepoint)

Aspherical coefficients

Second surface

$K=-1.2943$

$A_4=-9.84819\times10^{-6}$ $A_6=-2.39182\times10^{-8}$ $A_8=4.94427\times10^{-10}$

Third surface

$K=-0.2438$

$A_4=-1.13792\times10^{-4}$ $A_6=-6.83279\times10^{-8}$ $A_8=-6.63089\times10^{-9}$

Fourth surface

$K=-0.0218$

$A_4=6.76356\times10^{-5}$ $A_6=-1.19790\times10^{-7}$ $A_8=-2.64472\times10^{-9}$

Sixth surface

$K=-0.0422$

$A_4=-5.28848\times10^{-4}$ $A_6=2.13243\times10^{-6}$ $A_8=1.98353\times10^{-8}$

Eighth surface

$K=0.1608$

$A_4=1.86541\times10^{-4}$ $A_6=1.81579\times10^{-7}$ $A_8=3.74182\times10^{-8}$

Ninth surface

$K = 0.0115$

$A_4 = -3.79724 \times 10^{-5}$ $A_6 = -6.23075 \times 10^{-7}$

Twelfth surface

$K = 0.0000$

$A_4 = -1.19998 \times 10^{-3}$ $A_6 = 1.07234 \times 10^{-5}$

Fourteenth surface

$K = 0.0000$

$A_4 = 1.76029 \times 10^{-5}$ $A_6 = 3.42514 \times 10^{-7}$

Fifteenth surface

$K = 0.0000$

$A_4 = 6.14363 \times 10^{-5}$ $A_6 = 4.37825 \times 10^{-7}$

Zoom data

	Wide-angle position	Middle position	Telephoto position
D2	12.0419	7.5075	3.7196
D4	1.1332	8.3326	16.3538
D6	7.8982	5.2332	1.0000

mh = 10.098 mm

	Wide-angle position	Middle position	Telephoto position
f123	-10.392	-19.874	-41.387
m23	0.526	1.000	2.034
m2		-1.000	
m3		-1.000	

		Wide-angle position	Middle position	Telephoto position
Condition (9)	MG45	-0.768	-0.770	-0.772
Conditions (1), (7)	mh / fe	= 0.673		
Conditions (2), (3)	fe	= 15.010 mm		

Condition (8)	$\phi(mh / 2)$	= -0.377550 (1 / mm)
Condition (10)	$\beta 3$	= -1.000
Condition (11)	SF2	= -0.350
Condition (12)	f2 / f3	= -1.615
Condition (13)	fw / fFw	= -0.766
Condition (14)	fT / fFT	= -0.745
Condition (15)	mT / mW	= 3.872
Condition (16)	fw / fw123	= -0.766
Condition (17)	fT / fT123	= -0.745

Fifteenth embodiment

The real image mode finder optical system of this embodiment, as shown in Figs. 58A-58C, has nearly the same arrangement as that of the first embodiment with the exception of lens data.

Subsequently, numerical data of optical members constituting the real image mode finder optical system according to the fifteenth embodiment are shown below.

Numerical data 15

	Wide-angle position	Middle position	Telephoto position
m	0.429	0.813	1.663
ω (°)	33.665	17.724	8.889
f (mm)	7.384	13.997	28.641
Pupil dia. (mm)	4.000		

r_1 = 107.4567

d_1 = 1.0000 n_{d1} = 1.58423 ν_{d1} = 30.49

r_2 = 10.2589 (aspherical)

d_2 = D2 (variable)

r_3 = 10.2029 (aspherical)

d_3 = 4.4631 n_{d3} = 1.52542 ν_{d3} = 55.78

r_4 =-20.4728 (aspherical)

d_4 = D4 (variable)

r_5 =-9.3096 (aspherical)

d_5 =1.0000 n_{d5} =1.58425 ν_{d5} =30.35

r_6 =10.3604 (aspherical)

d_6 = D6 (variable)

r_7 =16.9815

d_7 =9.9000 n_{d7} =1.52542 ν_{d7} =55.78

r_8 =-13.8071 (aspherical)

d_8 =0.5000

r_9 =15.6162 (aspherical)

d_9 =22.4902 n_{d9} =1.52542 ν_{d9} =55.78

r_{10} =∞

d_{10} =2.3198

r_{11} =∞ (field frame)

d_{11} =3.8080

r_{12} =24.6624 (aspherical)

d_{12} =15.9445 n_{d12} =1.52542 ν_{d12} =55.78

r_{13} =-144.7239

d_{13} =2.0644

r_{14} =37.1434

d_{14} =4.1276 n_{d14} =1.52542 ν_{d14} =55.78

r_{15} =-14.1033 (aspherical)

d_{15} =16.7947

r_{16} =∞ (eyepoint)

Aspherical coefficients

Second surface

$K = -1.2993$

$A_4 = 5.71536 \times 10^{-5}$ $A_6 = -1.74731 \times 10^{-6}$ $A_8 = 9.48321 \times 10^{-9}$

Third surface

$K = -0.2562$

$A_4 = -1.82646 \times 10^{-5}$ $A_6 = -1.79005 \times 10^{-6}$ $A_8 = 5.13165 \times 10^{-9}$

Fourth surface

$K = -0.0200$

$A_4 = 1.47200 \times 10^{-4}$ $A_6 = -1.56976 \times 10^{-6}$ $A_8 = 1.27897 \times 10^{-8}$

Fifth surface

$K = 0.2127$

$A_4 = 5.41270 \times 10^{-4}$ $A_6 = -3.32639 \times 10^{-5}$ $A_8 = 5.81147 \times 10^{-7}$

Sixth surface

$K = -0.0433$

$A_4 = -1.09499 \times 10^{-4}$ $A_6 = -2.68424 \times 10^{-5}$ $A_8 = 6.74415 \times 10^{-7}$

Eighth surface

$K = 0.1546$

$A_4 = 2.00697 \times 10^{-4}$ $A_6 = -1.61566 \times 10^{-6}$ $A_8 = -3.13569 \times 10^{-9}$

Ninth surface

$K = 0.0164$

$A_4 = 6.95918 \times 10^{-5}$ $A_6 = -2.13186 \times 10^{-6}$

Twelfth surface

$K = 0.0000$

$A_4 = -4.54314 \times 10^{-4}$ $A_6 = -3.43968 \times 10^{-6}$

Fifteenth surface

$K = 0.0000$

$A_4 = 4.97954 \times 10^{-5}$ $A_6 = 1.10003 \times 10^{-7}$

Zoom data

	Wide-angle position	Middle position	Telephoto position
D2	11.2714	6.9682	3.2721
D4	1.6105	8.4616	16.2351
D6	7.6649	5.1170	1.0397

mh = 9.349 mm

	Wide-angle position	Middle position	Telephoto position
f123	-10.318	-19.605	-41.020
m23	0.530	1.000	2.042
m2		-1.000	
m3		-1.000	

		Wide-angle position	Middle position	Telephoto position
Condition (9)	MG45	-0.717	-0.720	-0.722

Conditions (1), (7)	mh / fe	= 0.543
Conditions (2), (3)	fe	= 17.226 mm
Condition (8)	ϕ(mh / 2)	= -0.390191 (1 / mm)
Condition (10)	β3	= -1.000
Condition (11)	SF2	= -0.335
Condition (12)	f2 / f3	= -1.656
Condition (13)	fw / fFw	= -0.716
Condition (14)	fT / fFT	= -0.698
Condition (15)	mT / mW	= 3.879
Condition (16)	fw / fw123	= -0.716
Condition (17)	fT / fT123	= -0.698

<u>Sixteenth embodiment</u>

The real image mode finder optical system of this embodiment, as shown in Figs. 59A-59C, has nearly the same arrangement as that of the first embodiment with the exception of lens data.

Subsequently, numerical data of optical members constituting the real image mode finder optical system according to the sixteenth embodiment are shown below.

Numerical data 16

	Wide-angle position	Middle position	Telephoto position
m	0.429	0.809	2.024
ω (°)	33.860	17.674	7.199
f (mm)	7.439	14.047	35.124

Pupil dia. (mm) 4.000

$r_1=244.6491$

$d_1=1.0000$ $n_{d1}=1.58423$ $\nu_{d1}=30.49$

$r_2=10.7182$ (aspherical)

$d_2=$ D2 (variable)

$r_3=9.8239$ (aspherical)

$d_3=4.5281$ $n_{d3}=1.52542$ $\nu_{d3}=55.78$

$r_4=-19.6580$ (aspherical)

$d_4=$ D4 (variable)

$r_5=-9.4259$ (aspherical)

$d_5=1.0000$ $n_{d5}=1.58425$ $\nu_{d5}=30.35$

$r_6=9.7259$ (aspherical)

$d_6=$ D6 (variable)

$r_7=13.6837$

$d_7=9.9000$ $n_{d7}=1.52542$ $\nu_{d7}=55.78$

$r_8=-17.5090$ (aspherical)

$d_8 = 0.5000$

$r_9 = 15.6690$ (aspherical)

$d_9 = 22.4657$ $n_{d9} = 1.52542$ $\nu_{d9} = 55.78$

$r_{10} = \infty$

$d_{10} = 2.3443$

$r_{11} = \infty$ (field frame)

$d_{11} = 4.2463$

$r_{12} = 24.2774$ (aspherical)

$d_{12} = 15.9476$ $n_{d12} = 1.52542$ $\nu_{d12} = 55.78$

$r_{13} = -225.2944$

$d_{13} = 2.0463$

$r_{14} = 37.1333$

$d_{14} = 3.6458$ $n_{d14} = 1.52542$ $\nu_{d14} = 55.78$

$r_{15} = -14.1787$ (aspherical)

$d_{15} = 16.8295$

$r_{16} = \infty$ (eyepoint)

Aspherical coefficients

Second surface

$K = -1.3022$

$A_4 = 1.94109 \times 10^{-5}$ $A_6 = -1.53742 \times 10^{-6}$ $A_8 = 9.18621 \times 10^{-9}$

Third surface

$K = -0.2549$

$A_4 = -7.62311 \times 10^{-5}$ $A_6 = -2.11044 \times 10^{-6}$ $A_8 = 9.22506 \times 10^{-9}$

Fourth surface

$K = -0.0175$

$A_4 = 1.18065 \times 10^{-4}$ $A_6 = -1.28525 \times 10^{-6}$ $A_8 = 1.15858 \times 10^{-8}$

Fifth surface

K $= 0.2594$

$A_4 = 7.73262 \times 10^{-4}$ $A_6 = -4.07569 \times 10^{-5}$ $A_8 = 6.35774 \times 10^{-7}$

Sixth surface

K $= -0.0434$

$A_4 = 2.49683 \times 10^{-5}$ $A_6 = -3.63701 \times 10^{-5}$ $A_8 = 8.31505 \times 10^{-7}$

Eighth surface

K $= 0.1534$

$A_4 = 1.67581 \times 10^{-4}$ $A_6 = -1.34210 \times 10^{-6}$ $A_8 = 5.76435 \times 10^{-9}$

Ninth surface

K $= 0.0177$

$A_4 = 9.17386 \times 10^{-6}$ $A_6 = -1.80151 \times 10^{-6}$

Twelfth surface

K $= 0.0000$

$A_4 = -3.02442 \times 10^{-4}$ $A_6 = -2.91068 \times 10^{-6}$

Fifteenth surface

K $= 0.0000$

$A_4 = 5.38216 \times 10^{-5}$ $A_6 = 6.59977 \times 10^{-8}$

Zoom data

	Wide-angle position	Middle position	Telephoto position
D2	10.3532	6.2169	1.8288
D4	1.2500	7.8558	17.6530
D6	8.8787	6.4091	1.0000

mh = 9.259 mm

	Wide-angle position	Middle position	Telephoto position
f123	-10.214	-19.332	-50.207

m23	0.532	1.000	2.500
m2		-1.000	
m3		-1.000	

		Wide-angle position	Middle position	Telephoto position
Condition (9)	MG45	-0.730	-0.732	-0.735
Conditions (1), (7)	mh / fe	= 0.534		
Conditions (2), (3)	fe	= 17.354 mm		
Condition (8)	ϕ(mh / 2)	= -0.263294 (1 / mm)		
Condition (10)	β3	= -1.000		
Condition (11)	SF2	= -0.334		
Condition (12)	f2 / f3	= -1.638		
Condition (13)	fw / fFw	= -0.728		
Condition (14)	fT / fFT	= -0.700		
Condition (15)	mT / mW	= 4.722		
Condition (16)	fw / fw123	= -0.728		
Condition (17)	fT / fT123	= -0.700		

Seventeenth embodiment

The real image mode finder optical system of this embodiment, as shown in Figs. 60A-60C, has nearly the same arrangement as that of the first embodiment with the exception of lens data.

Subsequently, numerical data of optical members constituting the real image mode finder optical system according to the seventeenth embodiment are shown below.

Numerical data 17

	Wide-angle position	Middle position	Telephoto position
m	0.427	0.806	2.149

ω (°)	34.100	17.683	6.723
f (mm)	7.358	13.901	37.053

Pupil dia. (mm) 4.000

$r_1 = -713.7698$

$d_1 = 1.0000$ $n_{d1} = 1.58423$ $\nu_{d1} = 30.49$

$r_2 = 11.0797$ (aspherical)

$d_2 =$ D2 (variable)

$r_3 = 9.7135$ (aspherical)

$d_3 = 4.6200$ $n_{d3} = 1.52542$ $\nu_{d3} = 55.78$

$r_4 = -18.4096$ (aspherical)

$d_4 =$ D4 (variable)

$r_5 = -9.1335$ (aspherical)

$d_5 = 1.0000$ $n_{d5} = 1.58425$ $\nu_{d5} = 30.35$

$r_6 = 9.4327$ (aspherical)

$d_6 =$ D6 (variable)

$r_7 = 13.0353$

$d_7 = 9.9000$ $n_{d7} = 1.52542$ $\nu_{d7} = 55.78$

$r_8 = -18.2574$ (aspherical)

$d_8 = 0.5000$

$r_9 = 15.8017$ (aspherical)

$d_9 = 22.4291$ $n_{d9} = 1.52542$ $\nu_{d9} = 55.78$

$r_{10} = \infty$

$d_{10} = 2.3809$

$r_{11} = \infty$ (field frame)

$d_{11} = 4.1914$

$r_{12} = 23.7178$ (aspherical)

$d_{12}=15.9419$ $n_{d12}=1.52542$ $\nu_{d12}=55.78$

$r_{13}=-188.7242$

$d_{13}=2.0225$

$r_{14}=38.0414$

$d_{14}=3.6351$ $n_{d14}=1.52542$ $\nu_{d14}=55.78$

$r_{15}=-14.0922$ (aspherical)

$d_{15}=16.8589$

$r_{16}=\infty$ (eyepoint)

Aspherical coefficients

Second surface

$K=-1.3025$

$A_4=-3.21798\times10^{-5}$ $A_6=-7.78889\times10^{-7}$ $A_8=5.08606\times10^{-9}$

Third surface

$K=-0.2547$

$A_4=-1.33313\times10^{-4}$ $A_6=-1.48099\times10^{-6}$ $A_8=7.55992\times10^{-9}$

Fourth surface

$K=-0.0172$

$A_4=1.11743\times10^{-4}$ $A_6=-9.24392\times10^{-7}$ $A_8=9.33552\times10^{-9}$

Fifth surface

$K=0.2714$

$A_4=1.27697\times10^{-3}$ $A_6=-8.18736\times10^{-5}$ $A_8=1.94631\times10^{-6}$

Sixth surface

$K=-0.0432$

$A_4=3.65213\times10^{-4}$ $A_6=-6.62961\times10^{-5}$ $A_8=1.63076\times10^{-6}$

Eighth surface

$K=0.1534$

$A_4 = 1.31305 \times 10^{-4}$ $A_6 = -7.77237 \times 10^{-7}$ $A_8 = 1.72405 \times 10^{-8}$

Ninth surface

$K = 0.0176$

$A_4 = -4.34110 \times 10^{-5}$ $A_6 = -9.40302 \times 10^{-7}$

Twelfth surface

$K = 0.0000$

$A_4 = -2.47396 \times 10^{-4}$ $A_6 = -3.97394 \times 10^{-6}$

Fifteenth surface

$K = 0.0000$

$A_4 = 5.72418 \times 10^{-5}$ $A_6 = 3.57168 \times 10^{-8}$

Zoom data

	Wide-angle position	Middle position	Telephoto position
D2	10.0156	5.9870	1.4776
D4	1.2500	7.6739	17.9124
D6	9.1244	6.7292	1.0000

mh = 9.156 mm

	Wide-angle position	Middle position	Telephoto position
f123	-9.916	-18.774	-52.236
m23	0.532	1.000	2.667
m2		-1.000	
m3		-1.000	

		Wide-angle position	Middle position	Telephoto position
Condition (9)	MG45	-0.744	-0.746	-0.748

Conditions (1), (7) mh / fe = 0.531

Conditions (2), (3) fe = 17.239 mm

Condition (8) $\phi(mh/2)$ = -0.251090 (1 / mm)

Condition (10)	$\beta 3$	= -1.000
Condition (11)	SF2	= -0.309
Condition (12)	f2 / f3	= -1.647
Condition (13)	fw / fFw	= -0.742
Condition (14)	fT / fFT	= -0.709
Condition (15)	mT / mW	= 5.035
Condition (16)	fw / fw123	= -0.742
Condition (17)	fT / fT123	= -0.709

Eighteenth embodiment

The real image mode finder optical system of this embodiment, as shown in Figs. 61A-61C, has nearly the same arrangement as that of the first embodiment with the exception of lens data.

Subsequently, numerical data of optical members constituting the real image mode finder optical system according to the eighteenth embodiment are shown below.

Numerical data 18

	Wide-angle position	Middle position	Telephoto position
m	0.435	0.824	1.691
ω (°)	33.426	17.596	8.847
f (mm)	7.656	14.498	29.743
Pupil dia. (mm)	4.000		

$r_1 = 99.5495$

$d_1 = 1.0000$ $n_{d1} = 1.58423$ $\nu_{d1} = 30.49$

$r_2 = 10.1706$ (aspherical)

$d_2 =$ D2 (variable)

$r_3 = 10.3729$ (aspherical)

$d_3 = 4.4126$ $n_{d3} = 1.52542$ $\nu_{d3} = 55.78$

$r_4 = -19.6559$ (aspherical)

$d_4 =$ D4 (aspherical)

$r_5 = -9.5997$ (aspherical)

$d_5 = 1.0000$ $n_{d5} = 1.58425$ $\nu_{d5} = 30.35$

$r_6 = 9.8997$ (aspherical)

$d_6 =$ D6 (variable)

$r_7 = 14.3933$

$d_7 = 9.9000$ $n_{d7} = 1.52542$ $\nu_{d7} = 55.78$

$r_8 = -15.6309$ (aspherical)

$d_8 = 0.5000$

$r_9 = 15.7116$ (aspherical)

$d_9 = 22.4940$ $n_{d9} = 1.52542$ $\nu_{d9} = 55.78$

$r_{10} = \infty$

$d_{10} = 2.3160$

$r_{11} = \infty$ (field frame)

$d_{11} = 3.6826$

$r_{12} = 27.7932$ (aspherical)

$d_{12} = 16.0681$ $n_{d12} = 1.52542$ $\nu_{d12} = 55.78$

$r_{13} = -173.7673$

$d_{13} = 2.3552$

$r_{14} = 35.5235$

$d_{14} = 4.0389$ $n_{d14} = 1.52542$ $\nu_{d14} = 55.78$

$r_{15} = -14.3073$ (aspherical)

$d_{15} = 22.5403$

$r_{16} = \infty$ (eyepoint)

Aspherical coefficients

Second surface

$K = -1.3005$

$A_4 = 6.14835 \times 10^{-5}$ $A_6 = -1.68311 \times 10^{-6}$ $A_8 = 8.77195 \times 10^{-9}$

Third surface

$K = -0.2546$

$A_4 = -2.04009 \times 10^{-6}$ $A_6 = -1.97626 \times 10^{-6}$ $A_8 = 8.97003 \times 10^{-9}$

Fourth surface

$K = -0.0188$

$A_4 = 1.56534 \times 10^{-4}$ $A_6 = -1.56324 \times 10^{-6}$ $A_8 = 1.26722 \times 10^{-8}$

Fifth surface

$K = 0.2126$

$A_4 = 4.66912 \times 10^{-4}$ $A_6 = -3.86240 \times 10^{-5}$ $A_8 = 1.14314 \times 10^{-6}$

Sixth surface

$K = -0.0436$

$A_4 = -2.20422 \times 10^{-4}$ $A_6 = -2.72889 \times 10^{-5}$ $A_8 = 8.43830 \times 10^{-7}$

Eighth surface

$K = 0.1534$

$A_4 = 2.24324 \times 10^{-4}$ $A_6 = -3.90532 \times 10^{-6}$ $A_8 = 2.12435 \times 10^{-8}$

Ninth surface

$K = 0.0178$

$A_4 = 4.50620 \times 10^{-5}$ $A_6 = -3.09867 \times 10^{-6}$

Twelfth surface

$K = 0.0000$

$A_4 = -7.56343 \times 10^{-4}$ $A_6 = 8.42941 \times 10^{-7}$

Fifteenth surface

$K = 0.0000$

$A_4 = 3.82666 \times 10^{-5}$ $A_6 = 2.37037 \times 10^{-7}$

Zoom data

	Wide-angle position	Middle position	Telephoto position
D2	11.1798	6.8982	3.2011
D4	1.7379	8.5495	16.3243
D6	7.6797	5.1496	1.0719

mh = 9.800 mm

	Wide-angle position	Middle position	Telephoto position
f123	-10.319	-19.589	-41.128
m23	0.530	1.000	2.048
m2		-1.000	
m3		-1.000	

		Wide-angle position	Middle position	Telephoto position
Condition (9)	MG45	-0.744	-0.746	-0.749

Conditions (1), (7)	mh / fe	= 0.557
Conditions (2), (3)	fe	= 17.593 mm
Condition (8)	ϕ(mh / 2)	= -0.484313 (1 / mm)
Condition (10)	β3	= -1.000
Condition (11)	SF2	= -0.309
Condition (12)	f2 / f3	= -1.663
Condition (13)	fw / fFw	= -0.742
Condition (14)	fT / fFT	= -0.723
Condition (15)	mT / mW	= 3.885
Condition (16)	fw / fw123	= -0.742
Condition (17)	fT / fT123	= -0.723

Nineteenth embodiment

In the real image mode finder optical system of this embodiment, as shown in Figs. 62A-62C, the objective optical system includes, in order from the object side, the first unit G1 with a negative refracting power, the second unit G2 with a positive refracting power, the third unit G3 with a negative refracting power, and the fourth unit G4 with a positive refracting power, and has a positive refracting power as a whole.

The fourth unit G4 is constructed with two prisms P1 and P2. The eyepiece optical system is constructed with the prism P and the positive lens E1 and has a positive refracting power as a whole.

The image erecting means includes the prisms P1 and P2 and the prism P. In the real image mode finder optical system of the nineteenth embodiment, the intermediate image formed by the objective optical system is interposed between the prism P2 and the prism P, and the field frame, such as that shown in Fig. 4, is provided in the proximity of its imaging position.

The magnification of the finder is changed in the range from the wide-angle position to the telephoto position by fixing the fourth unit G4 and by moving the first unit G1, the second unit G2, and the third unit G3 along the optical axis. In this case, the second unit G2 is simply moved toward the object side, and the third unit G3 toward the eyepiece side.

Each of the first unit G1, the second unit G2, and the third unit G3 is constructed with a single lens. The entrance surface and the exit surface of the prism P1 and the entrance surface of the prism P2 have curvatures. The entrance surface and the exit surface of the prism P also have curvatures.

The prisms P1 and P2 and the prism P are provided with the same reflecting surfaces as the reflecting surfaces $P1_1$, $P2_1$, $P2_2$, and P_1 in the first embodiment shown in Fig. 1-3, along the optical path, so that the optical axis is bent to erect an image. For example, one reflecting surface provided in the prism P1 bends the optical axis in the

Y-Z plane; two reflecting surfaces provided in the prism P2 bend the optical axis in the Y-Z plane and the X-Z plane in this order from the object side; and one reflecting surface provided in the prism P bends the optical axis in the X-Z plane. In this way, an erect image is obtained. Also, the arrangement of the reflecting surfaces is based on that of a Porro prism. Angles made with the optical axis bent by the reflecting surfaces are such that, for example, the angles of the optical axis bent by the reflecting surfaces of the prism P1 and the prism P are smaller than 90 degrees and the angles of the optical axis bent by the reflecting surfaces of the prism P2 are larger than 90 degrees. The reflecting surfaces of the prism P1 and the prism P are coated with metal films, such as silver and aluminum. The two reflecting surfaces of the prism P2 utilize total reflection.

However, the ways of bending the optical axis through the prisms and the angles of the optical axis bent by the reflecting surfaces are not limited to the above description. For example, the angle of the optical axis bent by the most field-frame-side reflecting surface of the prism P2 may be made smaller than 90 degrees so that this reflecting surface is coated with a metal film. Moreover, the angle of the optical axis bent by the reflecting surface of the prism P may also be made larger than 90 degrees so that this reflecting surface utilizes total reflection.

The positive lens E1 is constructed so that diopter adjustment can be made in accordance with an observer's diopter.

Subsequently, numerical data of optical members constituting the real image mode finder optical system according to the nineteenth embodiment are shown below.

Numerical data 19

	Wide-angle position	Middle position	Telephoto position
m	0.528	1.033	2.073
ω (°)	33.663	17.287	8.778

f (mm)	7.927	15.503	31.114
Pupil dia. (mm)	4.000		

$r_1 = 38.8071$

$d_1 = 1.0000$ $n_{d1} = 1.58423$ $\nu_{d1} = 30.49$

$r_2 = 8.9754$ (aspherical)

$d_2 =$ D2 (variable)

$r_3 = 9.9087$ (aspherical)

$d_3 = 4.3628$ $n_{d3} = 1.52542$ $\nu_{d3} = 55.78$

$r_4 = -23.7155$ (aspherical)

$d_4 =$ D4 (variable)

$r_5 = -10.0428$ (aspherical)

$d_5 = 1.0000$ $n_{d5} = 1.58425$ $\nu_{d5} = 30.35$

$r_6 = 10.3428$ (aspherical)

$d_6 =$ D6 (variable)

$r_7 = 11.5157$

$d_7 = 9.9000$ $n_{d7} = 1.52542$ $\nu_{d7} = 55.78$

$r_8 = -22.7435$ (aspherical)

$d_8 = 0.5000$

$r_9 = 15.4370$ (aspherical)

$d_9 = 22.2718$ $n_{d9} = 1.52542$ $\nu_{d9} = 55.78$

$r_{10} = \infty$

$d_{10} = 2.1155$

$r_{11} = \infty$ (field frame)

$d_{11} = 2.3895$

$r_{12} = 18.2155$ (aspherical)

$d_{12} = 15.5672$ $n_{d12} = 1.52542$ $\nu_{d12} = 55.78$

r_{13}=-36.4337

d_{13}=1.8054

r_{14}=26.1660

d_{14}=4.9762 n_{d14}=1.52542 ν_{d14}=55.78

r_{15}=-16.4971 (aspherical)

d_{15}=16.9055

$r_{16}=\infty$ (eyepoint)

Aspherical coefficients

Second surface

K =-1.2947

$A_4 = 2.38204\times10^{-5}$ $A_6 = 4.87600\times10^{-7}$ $A_8 = -3.73584\times10^{-9}$

Third surface

K =-0.2620

$A_4 = -1.35699\times10^{-4}$ $A_6 = 4.65011\times10^{-7}$ $A_8 = -1.87327\times10^{-8}$

Fourth surface

K =-0.0225

$A_4 = 4.04582\times10^{-5}$ $A_6 = 7.12976\times10^{-8}$ $A_8 = -9.76450\times10^{-9}$

Fifth surface

K =0.2139

$A_4 = 6.19005\times10^{-4}$ $A_6 = -3.14679\times10^{-5}$ $A_8 = 7.58697\times10^{-7}$

Sixth surface

K =-0.0424

$A_4 = 4.58626\times10^{-5}$ $A_6 = -2.40512\times10^{-5}$ $A_8 = 5.34729\times10^{-7}$

Eighth surface

K =0.1566

$A_4 = 2.05649\times10^{-4}$ $A_6 = 2.93949\times10^{-7}$ $A_8 = 2.68796\times10^{-8}$

Ninth surface

$K = 0.0143$

$A_4 = 7.12313 \times 10^{-6}$ $A_6 = -6.74794 \times 10^{-7}$

Twelfth surface

$K = 0.0000$

$A_4 = -1.15138 \times 10^{-3}$ $A_6 = 8.42829 \times 10^{-6}$

Fifteenth surface

$K = 0.0000$

$A_4 = 4.56110 \times 10^{-5}$ $A_6 = 1.18793 \times 10^{-7}$

Zoom data

	Wide-angle position	Middle position	Telephoto position
D2	11.7539	7.0573	3.4654
D4	1.2500	8.5614	16.1337
D6	8.1857	5.3729	1.0000

mh = 10.076 mm

	Wide-angle position	Middle position	Telephoto position
f123	-10.700	-21.016	-43.277
m23	0.529	1.032	2.072
m2		-1.000	
m3		-1.032	

		Wide-angle position	Middle position	Telephoto position
Condition (9)	MG45	-0.743	-0.744	-0.746
Conditions (1), (7)	mh / fe	= 0.671		
Conditions (2), (3)	fe	= 15.009 mm		
Condition (8)	ϕ(mh / 2)	= -0.451821 (1 / mm)		
Condition (10)	$\beta 3$	= -1.032		

Condition (11)	SF2	= -0.411
Condition (12)	f2 / f3	= -1.625
Condition (13)	fw / fFw	= -0.741
Condition (14)	fT / fFT	= -0.719
Condition (15)	mT / mW	= 3.925
Condition (16)	fw / fw123	= -0.741
Condition (17)	fT / fT123	= -0.719

Twentieth embodiment

The real image mode finder optical system of this embodiment, as shown in Figs. 63A-63C, has nearly the same arrangement as that of the nineteenth embodiment with the exception of lens data. A substantial difference with the nineteenth embodiment is that the exit surface of the prism P2 has a curvature in twentieth embodiment.

Subsequently, numerical data of optical members constituting the real image mode finder optical system according to the twentieth embodiment are shown below.

Numerical data 20

	Wide-angle position	Middle position	Telephoto position
m	0.557	1.038	2.023
ω (°)	32.360	17.517	9.010
f (mm)	8.356	15.584	30.363

Pupil dia. (mm) 4.000

r_1 = 59.2465

d_1 = 1.0000 n_{d1} = 1.58423 ν_{d1} = 30.49

r_2 = 8.3310 (aspherical)

d_2 = D2 (variable)

r_3 = 8.3856 (aspherical)

d_3 = 4.1672 n_{d3} = 1.49241 ν_{d3} = 57.66

$r_4 = -17.8798$

$d_4 =$ D4 (variable)

$r_5 = -13.7008$

$d_5 = 0.7000$ $n_{d5} = 1.58423$ $\nu_{d5} = 30.49$

$r_6 = 8.6409$ (aspherical)

$d_6 =$ D6 (variable)

$r_7 = 11.7739$

$d_7 = 9.8661$ $n_{d7} = 1.52542$ $\nu_{d7} = 55.78$

$r_8 = -29.5195$ (aspherical)

$d_8 = 1.0000$

$r_9 = 15.0708$

$d_9 = 22.3752$ $n_{d9} = 1.52542$ $\nu_{d9} = 55.78$

$r_{10} = -416.8001$

$d_{10} = 2.0410$

$r_{11} = \infty$ (field frame)

$d_{11} = 2.4340$

$r_{12} = 15.7244$ (aspherical)

$d_{12} = 18.3578$ $n_{d12} = 1.52542$ $\nu_{d12} = 55.78$

$r_{13} = -20.5538$

$d_{13} = 1.2739$

$r_{14} = 30.8079$ (aspherical)

$d_{14} = 3.4263$ $n_{d14} = 1.52542$ $\nu_{d14} = 55.78$

$r_{15} = -24.2754$ (aspherical)

$d_{15} = 15.7651$

$r_{16} = \infty$ (eyepoint)

Aspherical coefficients

Second surface

$K = -1.3070$

$A_4 = -5.42129 \times 10^{-5}$ $A_6 = 2.66433 \times 10^{-6}$ $A_8 = -1.96586 \times 10^{-8}$

Third surface

$K = -0.2445$

$A_4 = -3.33944 \times 10^{-4}$ $A_6 = 3.11379 \times 10^{-7}$ $A_8 = -1.64750 \times 10^{-8}$

Sixth surface

$K = -0.0650$

$A_4 = -5.31385 \times 10^{-4}$ $A_6 = 4.99350 \times 10^{-6}$ $A_8 = -6.09994 \times 10^{-8}$

Eighth surface

$K = 0.1673$

$A_4 = 2.10857 \times 10^{-4}$ $A_6 = 1.83918 \times 10^{-7}$ $A_8 = 3.12747 \times 10^{-8}$

Twelfth surface

$K = 0.0000$

$A_4 = -1.45924 \times 10^{-3}$ $A_6 = 1.59291 \times 10^{-5}$

Fourteenth

$K = 0.0000$

$A_4 = 7.03020 \times 10^{-5}$ $A_6 = 4.89240 \times 10^{-7}$

Fifteenth

$K = 0.0000$

$A_4 = 8.28668 \times 10^{-5}$ $A_6 = 3.99233 \times 10^{-7}$

Zoom data

	Wide-angle position	Middle position	Telephoto position
D2	11.8115	7.0078	2.9081
D4	1.0094	6.6799	14.3532
D6	7.7860	4.6744	1.0000

mh = 9.992 mm

	Wide-angle position	Middle position	Telephoto position
f123	-12.274	-23.044	-46.120
m23	0.734	1.370	2.676
m2		-1.000	
m3		-1.370	

		Wide-angle position	Middle position	Telephoto position
Condition (9)	MG45	-0.683	-0.683	-0.683

Conditions (1), (7)	mh / fe	= 0.666
Conditions (2), (3)	fe	= 15.010 mm
Condition (8)	ϕ(mh / 2)	= -0.322195 (1 / mm)
Condition (10)	β3	= -1.370
Condition (11)	SF2	= -0.361
Condition (12)	f2 / f3	= -1.364
Condition (13)	fw / fFw	= -0.681
Condition (14)	fT / fFT	= -0.658
Condition (15)	mT / mW	= 3.634
Condition (16)	fw / fw123	= -0.681
Condition (17)	fT / fT123	= -0.658

Twenty-first embodiment

In the real image mode finder optical system of this embodiment, as shown in Figs. 64A-64C, the objective optical system includes, in order from the object side, the first unit G1 with a negative refracting power, the second unit G2 with a positive refracting power, the third unit G3 with a negative refracting power, and the fourth unit G4 with a positive refracting power, and has a positive refracting power as a whole.

The fourth unit G4 is constructed with two prisms P1 and P2. The eyepiece op-

tical system is constructed with the prism P and the positive lens E1 and has a positive refracting power as a whole.

The image erecting means includes the prisms P1 and P2 and the prism P. In the real image mode finder optical system of the twenty-first embodiment, the intermediate image formed by the objective optical system is interposed between the prism P2 and the positive lens E1, and the field frame, such as that shown in Fig. 4, is provided in the proximity of its imaging position.

The magnification of the finder is changed in the range from the wide-angle position to the telephoto position by fixing the first unit G1 and the fourth unit G4 and by simply moving the second unit G2 toward the object side and the third unit G3 toward the eyepiece side along the optical axis.

Each of the first unit G1, the second unit G2, and the third unit G3 is constructed with a single lens. The entrance surface and the exit surface of the prism P1 and the entrance surface of the prism P2 have curvatures. The entrance surface and the exit surface of the prism P also have curvatures.

The prisms P1 and P2 and the prism P, as shown in Figs. 65-67, are provided with reflecting surfaces $P1_1$, $P2_1$, $P2_2$, and P_1 along the optical path so that the optical axis is bent to erect an image. Specifically, as shown in Fig. 66, the reflecting surface $P1_1$ provided in the prism P1 bends the optical axis in a Y-Z plane; as shown in Fig. 67, the two reflecting surfaces $P2_1$ and $P2_2$ provided in the prism P2 bend the optical axis twice in the X-Y plane in this order from the object side; and as shown in Fig. 66, the reflecting surface P_1 provided in the prism P bends the optical axis in the Y-Z plane. In this way, an erect image is obtained. Also, the arrangement of the reflecting surfaces is based on that of a Porro prism. Angles made with the optical axis bent by the reflecting surfaces are 90 degrees. The reflecting surfaces $P1_1$, $P2_1$, and $P2_2$ of the prism P1 and the prism P2 are coated with metal films, such as silver and aluminum.

The reflecting surface P_1 of the prism P utilizes total reflection.

However, the ways of bending the optical axis through the prisms and the angles of the optical axis bent by the reflecting surfaces are not limited to the above description. For example, the angle of the optical axis bent by one reflecting surface of the prism P2 may be made smaller than 90 degrees so that this reflecting surface is coated with a metal film. Moreover, the angle of the optical axis bent by the other reflecting surface of the prism P2 may also be made larger than 90 degrees so that this reflecting surface utilizes total reflection.

The positive lens E1 is constructed so that diopter adjustment can be made in accordance with an observer's diopter.

Subsequently, numerical data of optical members constituting the real image mode finder optical system according to the twenty-first embodiment are shown below.

Numerical data 21

	Wide-angle position	Middle position	Telephoto position
m	0.394	0.659	1.049
ω (°)	32.118	19.007	12.091
f (mm)	6.866	11.492	18.288

Pupil dia. (mm) 5.000

r_1 = -59.3919

d_1 = 1.0000 n_{d1} = 1.58423 ν_{d1} = 30.49

r_2 = 10.3748 8 (aspherical)

d_2 = D2 (variable)

r_3 = 14.1522 (aspherical)

d_3 = 3.7000 n_{d3} = 1.52542 ν_{d3} = 55.78

r_4 = -9.2660 (aspherical)

d_4 = D4 (variable)

r_5=-7.5095 (aspherical)

d_5=1.0000 n_{d5}=1.58425 ν_{d5}=30.35

r_6=13.7636

d_6= D6 (variable)

r_7=20.3870

d_7=10.0000 n_{d7}=1.52542 ν_{d7}=55.78

r_8=-13.4385 (aspherical)

d_8=0.4000

r_9=12.4702 (aspherical)

d_9=22.0000 n_{d9}=1.52542 ν_{d9}=55.78

$r_{10}=\infty$

d_{10}=2.0000

$r_{11}=\infty$ (field frame)

d_{11}=7.9991

r_{12}=18.8914 (aspherical)

d_{12}=3.1688 n_{d12}=1.52542 ν_{d12}=55.78

r_{13}=-15.1681

d_{13}=2.0000

r_{14}=-13.4956 (aspherical)

d_{14}=12.2000 n_{d14}=1.52542 ν_{d14}=55.78

r_{15}=-10.7971 (aspherical)

d_{15}=13.5000

$r_{16}=\infty$ (eyepoint)

Aspherical coefficients

Second surface

K =-1.8801

$A_4 = 8.93195 \times 10^{-5}$ $A_6 = -1.59803 \times 10^{-5}$ $A_8 = 2.26734 \times 10^{-7}$

Third surface

$K = -26.0761$

$A_4 = 8.01991 \times 10^{-4}$ $A_6 = -1.09865 \times 10^{-4}$ $A_8 = 4.19307 \times 10^{-6}$

$A_{10} = -1.65929 \times 10^{-7}$

Fourth surface

$K = 0.7079$

$A_4 = 1.90150 \times 10^{-4}$ $A_6 = -3.87917 \times 10^{-5}$ $A_8 = 8.76025 \times 10^{-7}$

$A_{10} = -3.24756 \times 10^{-8}$

Fifth surface

$K = -0.4742$

$A_4 = 4.50016 \times 10^{-4}$ $A_6 = 4.48738 \times 10^{-5}$ $A_8 = -3.79556 \times 10^{-6}$

Eighth surface

$K = 0.8140$

$A_4 = -1.12430 \times 10^{-3}$ $A_6 = 5.37408 \times 10^{-5}$ $A_8 = -1.01121 \times 10^{-6}$

Ninth surface

$K = -2.4434$

$A_4 = -1.05938 \times 10^{-3}$ $A_6 = 4.60167 \times 10^{-5}$ $A_8 = -8.38383 \times 10^{-7}$

Twelfth surface

$K = 0.0000$

$A_4 = 4.97477 \times 10^{-4}$ $A_6 = -3.14535 \times 10^{-5}$ $A_8 = -3.04078 \times 10^{-8}$

Fourteenth surface

$K = 0.0000$

$A_4 = -8.27827 \times 10^{-4}$ $A_6 = 5.41341 \times 10^{-5}$ $A_8 = -6.06561 \times 10^{-7}$

Fifteenth surface

$K = 0.0000$

$A_4 = -4.89807 \times 10^{-6}$ $A_6 = 7.07749 \times 10^{-6}$ $A_8 = -9.70475 \times 10^{-8}$

Zoom data

	Wide-angle position	Middle position	Telephoto position
D2	8.2666	5.9354	3.4477
D4	0.8000	5.6220	10.2589
D6	5.3399	2.8492	0.7000

mh = 8.240 mm

	Wide-angle position	Middle position	Telephoto position
f123	-9.787	-16.419	-26.311
m23	0.651	1.088	1.729
m2		-1.000	
m3		-1.088	

		Wide-angle position	Middle position	Telephoto position
Condition (9)	MG45	-0.703	-0.704	-0.705

Conditions (1), (7)	mh / fe	= 0.473
Conditions (2), (3)	fe	= 17.434 mm
Condition (10)	β3	= -1.088
Condition (11)	SF2	= 0.209
Condition (12)	f2 / f3	= -1.379
Condition (13)	fw / fFw	= -0.702
Condition (14)	fT / fFT	= -0.695
Condition (15)	mT / mW	= 2.663
Condition (16)	fw / fw123	= -0.702
Condition (17)	fT / fT123	= -0.695

Twenty-second embodiment

In the real image mode finder optical system of this embodiment, as shown in

Figs. 68A-68C, the objective optical system includes, in order from the object side, the first unit G1 with a negative refracting power, the second unit G2 with a positive refracting power, the third unit G3 with a negative refracting power, and the fourth unit G4 with a positive refracting power, and has a positive refracting power as a whole.

The fourth unit G4 is constructed with the positive lens L1 and the prism P1. The eyepiece optical system is constructed with the prism P and the positive lens E1 and has a positive refracting power as a whole.

The image erecting means includes the prism P1 and the prism P. In the real image mode finder optical system of the second embodiment, the intermediate image formed by the objective optical system is interposed between the prism P1 and the prism P, and the field frame, such as that shown in Fig. 4, is provided in the proximity of its imaging position.

The magnification of the finder is changed in the range from the wide-angle position to the telephoto position by fixing the first unit G1 and the fourth unit G4 and by simply moving the second unit G2 toward the object side and the third unit G3 toward the eyepiece side along the optical axis.

Each of the first unit G1, the second unit G2, and the third unit G3 is constructed with a single lens. The entrance surface of the prism P1 has a curvature. The entrance surface and the exit surface of the prism P also have curvatures.

The prism P1 and the prism P are provided with reflecting surfaces along the optical path so that the optical axis is bent to obtain an erect image. For example, the prism P1 is provided with three reflecting surfaces for bending the optical axis twice in the Y-Z plane and once in the X-Z plane in this order from the object side, and the prism P is provided with one reflecting surface for bending the optical axis in the X-Z plane to erect the image. Also, the arrangement of the reflecting surfaces is based on that of a Porro prism. Angles made with the optical axis bent by the reflecting sur-

faces are such that, for example, the angle of the optical axis bent by one reflecting surface of the prism P1 is smaller than 90 degrees and the angles of the optical axis bent by the remaining two reflecting surfaces are larger than 90 degrees, while the angle of the optical axis bent by the reflecting surface of the prism P is smaller than 90 degrees. The reflecting surfaces making angles smaller than 90 degrees are coated with metal films, such as silver and aluminum. The reflecting surfaces of angles larger than 90 degrees utilize total reflection.

However, the angles of the optical axis bent by the reflecting surfaces are not limited to the above description. For example, the angle of the optical axis bent by the most field-frame-side reflecting surface of the prism P1 may be made smaller than 90 degrees so that this reflecting surface is coated with a metal film. Moreover, the angle of the optical axis bent by the reflecting surface of the prism P may also be made larger than 90 degrees so that this reflecting surface utilizes total reflection.

The positive lens E1 is constructed so that diopter adjustment can be made in accordance with an observer's diopter.

Subsequently, numerical data of optical members constituting the real image mode finder optical system according to the twenty-second embodiment are shown below.

<u>Numerical data 22</u>

	Wide-angle position	Middle position	Telephoto position
m	0.710	1.045	2.031
ω (°)	26.166	17.592	9.011
f (mm)	10.647	15.663	30.438

Pupil dia. (mm) 4.000

$r_1 = 94.9717$

$d_1 = 0.9721$ $n_{d1} = 1.58423$ $\nu_{d1} = 30.49$

$r_2 = 9.3965$ (aspherical)

$d_2 =$ D2 (variable)

$r_3 = 9.8091$ (aspherical)

$d_3 = 4.2874$ $n_{d3} = 1.52542$ $\nu_{d3} = 55.78$

$r_4 = -25.4274$ (aspherical)

$d_4 =$ D4 (variable)

$r_5 = -16.9121$

$d_5 = 1.0000$ $n_{d5} = 1.58423$ $\nu_{d5} = 30.49$

$r_6 = 15.2040$ (aspherical)

$d_6 =$ D6 (variable)

$r_7 = 40.9744$

$d_7 = 3.5824$ $n_{d7} = 1.52542$ $\nu_{d7} = 55.78$

$r_8 = -14.7461$ (aspherical)

$d_8 = 0.5000$

$r_9 = 21.4998$ (aspherical)

$d_9 = 28.4133$ $n_{d9} = 1.52542$ $\nu_{d9} = 55.78$

$r_{10} = \infty$

$d_{10} = 1.8195$

$r_{11} = \infty$ (field frame)

$d_{11} = 2.3065$

$r_{12} = 15.5002$ (aspherical)

$d_{12} = 15.7893$ $n_{d12} = 1.52542$ $\nu_{d12} = 55.78$

$r_{13} = -35.0088$

$d_{13} = 1.9666$

$r_{14} = 27.5692$ (aspherical)

$d_{14} = 5.0860$ $n_{d14} = 1.52542$ $\nu_{d14} = 55.78$

$r_{15} = -16.2713$ (aspherical)

$d_{15} = 16.9035$

$r_{16} = \infty$ (eyepoint)

Aspherical coefficients

Second surface

$K = -1.2960$

$A_4 = 2.42034 \times 10^{-5}$ $A_6 = -4.03294 \times 10^{-7}$ $A_8 = -3.85761 \times 10^{-10}$

Third surface

$K = -0.2523$

$A_4 = -1.40079 \times 10^{-4}$ $A_6 = 9.09631 \times 10^{-8}$ $A_8 = -7.25698 \times 10^{-9}$

Fourth surface

$K = -0.0226$

$A_4 = 2.34829 \times 10^{-5}$ $A_6 = 6.60458 \times 10^{-7}$ $A_8 = -6.09388 \times 10^{-9}$

Sixth surface

$K = -0.0504$

$A_4 = -1.07083 \times 10^{-4}$ $A_6 = 1.32744 \times 10^{-6}$ $A_8 = -4.22406 \times 10^{-9}$

Eighth surface

$K = 0.1637$

$A_4 = 5.89020 \times 10^{-5}$ $A_6 = 2.51165 \times 10^{-7}$ $A_8 = 1.03528 \times 10^{-8}$

Ninth surface

$K = 0.0039$

$A_4 = -3.04882 \times 10^{-6}$ $A_6 = 4.78283 \times 10^{-7}$

Twelfth surface

$K = 0.0000$

$A_4 = -1.19998 \times 10^{-3}$ $A_6 = 1.07234 \times 10^{-5}$

Fourteenth surface

$K = 0.0000$

$A_4 = 3.35581 \times 10^{-5}$ $A_6 = -1.60128 \times 10^{-7}$

Fifteenth surface

$K = 0.0000$

$A_4 = 7.31972 \times 10^{-5}$ $A_6 = 9.93972 \times 10^{-9}$

Zoom data

	Wide-angle position	Middle position	Telephoto position
D2	8.3076	6.0828	3.0961
D4	1.1490	6.5799	16.8299
D6	11.9688	8.7628	1.4995

mh = 9.844 mm

	Wide-angle position	Middle position	Telephoto position
f123	-21.628	-32.011	-64.323
m23	1.204	1.771	3.458
m2		-1.328	
m3		-1.333	

		Wide-angle position	Middle position	Telephoto position
Condition (9)	MG45	-0.495	-0.495	-0.495

Conditions (1), (7) mh / fe = 0.657

Conditions (2), (3) fe = 14.990 mm

Condition (11) SF2 = -0.443

Condition (12) F2 / f3 = -1.038

Condition (13) fw / fFw = -0.492

Condition (14) fT / fFT = -0.473

Condition (15) mT / mW = 2.859

Condition (16) fw / fw123 = -0.492

Condition (17) fT / fT123 = -0.473

Twenty-third embodiment

The real image mode finder optical system of this embodiment, as shown in Figs. 69A-69C, has nearly the same arrangement as that of the twenty-first embodiment with the exception of lens data.

Subsequently, numerical data of optical members constituting the real image mode finder optical system according to the twenty-third embodiment are shown below.

Numerical data 23

	Wide-angle position	Middle position	Telephoto position
m	0.574	0.905	1.568
ω (°)	24.652	15.498	8.841
f (mm)	10.617	16.725	28.996

Pupil dia. (mm) 4.000

r_1 = -920.9537

d_1 = 1.0000 n_{d1} = 1.58423 ν_{d1} = 30.49

r_2 = 9.9330 (aspherical)

d_2 = D2 (variable)

r_3 = 9.6882 (aspherical)

d_3 = 4.1510 n_{d3} = 1.52542 ν_{d3} = 55.78

r_4 = -23.0106 (aspherical)

d_4 = D4 (variable)

r_5 = -14.4812 (aspherical)

d_5 = 1.0000 n_{d5} = 1.58425 ν_{d5} = 30.35

r_6 = 14.7812 (aspherical)

d_6 = D6 (variable)

r_7 = 11.6881

d_7 = 10.4000 n_{d7} = 1.52542 ν_{d7} = 55.78

$r_8 = -44.1162$ (aspherical)

$d_8 = 0.5000$

$r_9 = 19.0394$ (aspherical)

$d_9 = 21.0918$ $n_{d9} = 1.52542$ $\nu_{d9} = 55.78$

$r_{10} = \infty$

$d_{10} = 2.9577$

$r_{11} = \infty$ (field frame)

$d_{11} = 8.6051$

$r_{12} = 18.8914$ (aspherical)

$d_{12} = 3.0466$ $n_{d12} = 1.52542$ $\nu_{d12} = 55.78$

$r_{13} = -19.3762$

$d_{13} = 2.5000$

$r_{14} = -22.1615$ (aspherical)

$d_{14} = 14.0000$ $n_{d14} = 1.52542$ $\nu_{d14} = 55.78$

$r_{15} = -13.1330$ (aspherical)

$d_{15} = 16.9541$

$r_{16} = \infty$ (eyepoint)

Aspherical coefficients

Second surface

$K = -1.2958$

$A_4 = -1.37883 \times 10^{-4}$ $A_6 = 3.49813 \times 10^{-6}$ $A_8 = -2.85996 \times 10^{-8}$

Third surface

$K = -0.2610$

$A_4 = -2.84178 \times 10^{-4}$ $A_6 = 2.18425 \times 10^{-6}$ $A_8 = 1.89724 \times 10^{-8}$

Fourth surface

$K = -0.0222$

$A_4 = -3.94404 \times 10^{-5}$ $A_6 = 2.36146 \times 10^{-6}$ $A_8 = 1.07129 \times 10^{-8}$

Fifth surface

$K = 0.2136$

$A_4 = 7.49839 \times 10^{-4}$ $A_6 = -3.41182 \times 10^{-5}$ $A_8 = 9.01815 \times 10^{-7}$

Sixth surface

$K = -0.0419$

$A_4 = 6.33920 \times 10^{-4}$ $A_6 = -3.96052 \times 10^{-5}$ $A_8 = 1.13002 \times 10^{-6}$

Eighth surface

$K = 0.1567$

$A_4 = 1.02994 \times 10^{-4}$ $A_6 = 3.46598 \times 10^{-6}$ $A_8 = 6.31270 \times 10^{-9}$

Ninth surface

$K = 0.0129$

$A_4 = -6.13561 \times 10^{-5}$ $A_6 = 1.96098 \times 10^{-6}$

Twelfth surface

$K = 0.0000$

$A_4 = -1.14754 \times 10^{-4}$ $A_6 = 2.96268 \times 10^{-6}$ $A_8 = -4.33585 \times 10^{-8}$

Fourteenth surface

$K = 0.0000$

$A_4 = -1.44350 \times 10^{-4}$ $A_6 = -3.21946 \times 10^{-6}$ $A_8 = 6.14512 \times 10^{-8}$

Fifteenth surface

$K = 0.0000$

$A_4 = -7.32422 \times 10^{-6}$ $A_6 = 5.88495 \times 10^{-7}$ $A_8 = -9.09150 \times 10^{-10}$

Zoom data

	Wide-angle position	Middle position	Telephoto position
D2	8.4479	5.9380	3.5969
D4	2.3409	8.3613	16.2888

D6	10.0702	6.5597	0.9733

mh = 9.332 mm

	Wide-angle position	Middle position	Telephoto position
f123	-20.012	-31.646	-56.048
m23	1.168	1.864	3.229
m2		-1.365	
m3		-1.365	

		Wide-angle position	Middle position	Telephoto position
Condition (9)	MG45	-0.533	-0.535	-0.537
Conditions (1), (7)	mh / fe	= 0.505		
Conditions (2), (3)	fe	= 18.490 mm		
Condition (11)	SF2	= -0.407		
Condition (12)	F2 / f3	= -1.097		
Condition (13)	fw / fFw	= -0.530		
Condition (14)	fT / fFT	= -0.517		
Condition (15)	mT / mW	= 2.731		
Condition (16)	fw / fw123	= -0.530		
Condition (17)	fT / fT123	= -0.517		

Twenty-fourth embodiment

In the real image mode finder optical system of this embodiment, as shown in Figs. 70A-70C, the objective optical system includes, in order from the object side, the first unit G1 with a negative refracting power, the second unit G2 with a positive refracting power, the third unit G3 with a negative refracting power, and the fourth unit G4 with a positive refracting power, and has a positive refracting power as a whole.

The fourth unit G4 is constructed with the positive lens L1 and the prism P1. The eyepiece optical system is constructed with the positive lens E1 and the prism P

and has a positive refracting power as a whole.

The image erecting means includes the prism P1 and the prism P. In the real image mode finder optical system of the twenty-fourth embodiment, the intermediate image formed by the objective optical system is interposed between the prism P1 and the positive lens E1, and the field frame, such as that shown in Fig. 4, is provided in the proximity of its imaging position.

The magnification of the finder is changed in the range from the wide-angle position to the telephoto position by fixing the first unit G1 and the fourth unit G4 and by simply moving the second unit G2 toward the object side and the third unit G3 toward the eyepiece side along the optical axis.

Each of the first unit G1, the second unit G2, and the third unit G3 is constructed with a single lens. The entrance surface of the prism P1 has a curvature. The entrance surface and the exit surface of the prism P also have curvatures.

The prism P1 and the prism P are provided with reflecting surfaces along the optical path so that the optical axis is bent to obtain an erect image. For example, the prism P1 is provided with three reflecting surfaces for bending the optical axis once in the Y-Z plane and twice in the X-Y plane in this order from the object side, and the prism P is provided with one reflecting surface for bending the optical axis in the Y-Z plane to erect the image. Also, the arrangement of the reflecting surfaces is based on that of a Porro prism. Angles made with the optical axis bent by the reflecting surfaces are such that, for example, the angles of the optical axis bent by the reflecting surfaces of the prism P1 are smaller than 90 degrees. The three reflecting surfaces of the prism P1 are coated with metal films, such as silver and aluminum. The reflecting surface of the prism P utilizes total reflection.

However, the ways of bending the optical axis through the prisms and the angles of the optical axis bent by the reflecting surfaces are not limited to the above descrip-

tion. For example, the angle of the optical axis bent by the most field-frame-side reflecting surface of the prism P1 may be made smaller than 90 degrees so that this reflecting surface is coated with a metal film. Moreover, the angle of the optical axis bent by the second reflecting surface, from the field frame side, of the prism P1 may also be made larger than 90 degrees so that this reflecting surface utilizes total reflection.

The positive lens E1 is constructed so that diopter adjustment can be made in accordance with an observer's diopter.

Subsequently, numerical data of optical members constituting the real image mode finder optical system according to the twenty-fourth embodiment are shown below.

Numerical data 24

	Wide-angle position	Middle position	Telephoto position
m	0.457	0.775	1.602
ω (°)	30.208	17.858	8.701
f (mm)	8.505	14.412	29.797

Pupil dia. (mm) 4.000

$r_1 = 75.2465$

$d_1 = 1.0000$ $n_{d1} = 1.58423$ $\nu_{d1} = 30.49$

$r_2 = 8.8816$ (aspherical)

$d_2 =$ D2 (variable)

$r_3 = 10.2728$ (aspherical)

$d_3 = 4.1473$ $n_{d3} = 1.52542$ $\nu_{d3} = 55.78$

$r_4 = -18.0037$ (aspherical)

$d_4 =$ D4 (variable)

$r_5 = -10.0864$ (aspherical)

$d_5 = 1.0000$ $n_{d5} = 1.58425$ $\nu_{d5} = 30.35$

$r_6 = 10.3864$ (aspherical)

$d_6 =$ D6 (variable)

$r_7 = 19.6921$

$d_7 = 4.3014$ $n_{d7} = 1.52542$ $\nu_{d7} = 55.78$

$r_8 = -13.1461$ (aspherical)

$d_8 = 0.5000$

$r_9 = 21.4624$ (aspherical)

$d_9 = 27.5577$ $n_{d9} = 1.52542$ $\nu_{d9} = 55.78$

$r_{10} = \infty$

$d_{10} = 2.1330$

$r_{11} = \infty$ (field frame)

$d_{11} = 8.3794$

$r_{12} = 18.8914$ (aspherical)

$d_{12} = 3.1249$ $n_{d12} = 1.52542$ $\nu_{d12} = 55.78$

$r_{13} = -18.8429$

$d_{13} = 2.5000$

$r_{14} = -19.8984$ (aspherical)

$d_{14} = 14.0000$ $n_{d14} = 1.52542$ $\nu_{d14} = 55.78$

$r_{15} = -12.6982$ (aspherical)

$d_{15} = 16.9541$

$r_{16} = \infty$ (eyepoint)

Aspherical coefficients

Second surface

$K = -1.2958$

$A_4 = 3.44925 \times 10^{-6}$ $A_6 = 4.20426 \times 10^{-7}$ $A_8 = -7.66223 \times 10^{-9}$

Third surface

$K = -0.2616$

$A_4 = -2.70426 \times 10^{-4}$ $A_6 = 1.77644 \times 10^{-6}$ $A_8 = -2.00847 \times 10^{-7}$

Fourth surface

$K = -0.0223$

$A_4 = -7.38297 \times 10^{-5}$ $A_6 = 6.70806 \times 10^{-7}$ $A_8 = -1.54652 \times 10^{-7}$

Fifth surface

$K = 0.2135$

$A_4 = 3.49998 \times 10^{-4}$ $A_6 = -1.71207 \times 10^{-5}$ $A_8 = 3.68862 \times 10^{-7}$

Sixth surface

$K = -0.0430$

$A_4 = -1.78394 \times 10^{-4}$ $A_6 = -7.98576 \times 10^{-6}$ $A_8 = 1.76981 \times 10^{-7}$

Eighth surface

$K = 0.1579$

$A_4 = 4.99038 \times 10^{-6}$ $A_6 = 8.82927 \times 10^{-7}$ $A_8 = 1.18585 \times 10^{-8}$

Ninth surface

$K = 0.0120$

$A_4 = -1.28730 \times 10^{-4}$ $A_6 = 5.21275 \times 10^{-7}$

Twelfth surface

$K = 0.0000$

$A_4 = -2.49634 \times 10^{-4}$ $A_6 = 1.72455 \times 10^{-7}$ $A_8 = 2.31794 \times 10^{-9}$

Fourteenth surface

$K = 0.0000$

$A_4 = 8.06332 \times 10^{-6}$ $A_6 = 4.07603 \times 10^{-7}$ $A_8 = -1.41628 \times 10^{-8}$

Fifteenth surface

$K = 0.0000$

$A_4 = 3.96776 \times 10^{-5}$ $A_6 = 5.11111 \times 10^{-8}$ $A_8 = -1.38979 \times 10^{-10}$

Zoom data

	Wide-angle position	Middle position	Telephoto position
D2	11.4348	8.0329	4.3575
D4	1.2500	6.8862	14.8224
D6	8.1779	5.9436	1.6828

mh = 9.391 mm

	Wide-angle position	Middle position	Telephoto position
f123	-10.255	-17.402	-36.720
m23	0.592	1.000	2.070
m2		-1.000	
m3		-1.000	

		Wide-angle position	Middle position	Telephoto position
Condition (9)	MG45	-0.831	-0.834	-0.837
Conditions (1), (7)	mh / fe	= 0.505		
Conditions (2), (3)	fe	= 18.603 mm		
Condition (8)	ϕ(mh / 2)	= -0.118345 (1 / mm)		
Condition (10)	β3	= -1.000		
Condition (11)	SF2	= -0.273		
Condition (12)	F2 / f3	= -1.524		
Condition (13)	fw / fFw	= -0.829		
Condition (14)	fT / fFT	= -0.811		
Condition (15)	mT / mW	= 3.503		
Condition (16)	fw / fw123	= -0.829		
Condition (17)	fT / fT123	= -0.811		

The real image mode finder optical system according to the present invention constructed as mentoned above can be used in any of various photographing

apparatuses, such as compact cameras, for example, 35 mm film cameras and APS film cameras; digital cameras using electronic image sensors, for example, CCDs and CMOS sensors; and video movies. A specific application example of this finder optical system will be described below.

Figs. 71- 73 show an example of an electromic camera incorporating the real image mode finder optical system of the present invention.

As shown in Figs. 71-73, an electronic camera 200 includes a photographing optical system 202 having a photpgraphing optical path 201, a finder optical system 204 of the present invention having a finder optical path 203, a release button 205, a stroboscopic lamp 206, and a liquid crystal display monitor 207. When the release button 205 provided on the upper surface of the electronic camera 200 is pushd, photographing is performed through the photographing optical system 202 in association with the release button 205. An object image formed by the photographing optical system 202 falls on an image senser chip 209, such as a CCD, through various filters 208, such as an IR (infrared) cutoff filter and a low-pass filter.

The object image received by the image sensor chip 209 is displayed, as an electronic image, on the liquid crystal display monitor 207 provided on the back surface of the electronic camera 200 through a processing means 211 electrically connected with terminals 210. The processing means 211 controls a recording means 212 for recording the object image received by the image sensor chip 209 as electronic information. The recording means 212 is electrocally connected with the processing means 211. Also, the recording means 212 may be replaced with a device for writing the record in a recording medium, such as a floppy disk, a smart medium, or memory card.

Where the photographing optical system 202 is constructed as a zoom lens, the finder optical system 204 having the finder optical path 203 may use the real image

mode finder optical system of any of the above embodiments. Where the photographing optical system 202 is a single focus optical system, the objective optical system in the finder optical system 204 may be replaced with a single focus objective optical system in which a photographing area can be observed.

For the image erecting means, any means which is capable of erecting an image, not to speak of the Porro prism, is satisfactory. For example, when a roof reflecting surface is used as the image erecting means so that the objective optical system includes the roof reflecting surface and one planar reflecting surface and the eyepiece optical system includes one planar reflecting surface, compactness of the entire camera can be achieved. The reflecting surfaces are not limited to planar surfaces and may be configured as curved surfaces.

Even when a photographing film is used instead of the image sensor chip 209, a compact film camera with an excellent view can be obtained.

Figs. 74A-74C show a specific example of a photographing zoom lens used in a compact camera for a 35 mm film (the maximum image height of 21. 6 mm).

The photographing zoom lens includes, in order from the object side, the first unit G1 with a positive refracting power; the second unit G2 with a negative refracting power, having an aperture stop S which is variable in aperture diameter, at the most object-side position; and the third unit G3 with a negative refracting power. When the magnification of the finder is changed in the range from the wide-angle position to the telephoto position, a space between the first unit and the second unit is continuously widened, and a space between the second unit and the third unit is contunuously narrowed, so that the first unit and the third unit are integrally constructed and the first unit, the second unit, and the third unit are continuously moved toward the object side, thereby forming the object image on a film surface.

Subsequently, numerical data of optical members constituting the photographing

zoom lens are shown below. In the numerical data, f represents the focal length of the photographing zoom lens, ω represents a half angle of view, Fno represents an F-number, and bf represents a back focal distance. Other symbols are the same as those used in the numerical data of the embodiments.

Numerical data (photographing zoom lens)

	Wide-angle position	Middle position	Telephoto position
f (mm)	29.31	72.87	135.00
ω (°)	28.3	16.1	9.0
Fno	4.1	6.8	11.5
bf (mm)	9.47732	31.48343	71.3185

r_1=-180.6198

d_1=1.2001 n_{d1}=1.76182 ν_{d1}=26.52

r_2=180.6198

d_2=0.2286

r_3=21.6168

d_3=3.1212 n_{d3}=1.49700 ν_{d3}=81.54

r_4=-380.8986

d_4= D4 (variable)

r_5=∞ (stop)

d_5=1.0000

r_6=-16.3795

d_6=1.0004 n_{d6}=1.77250 ν_{d6}=49.60

r_7=12.8963

d_7=3.1001 n_{d7}=1.72825 ν_{d7}=28.46

r_8=-134.5936

d_8=0.4702

$r_9 = 31.9527$

$d_9 = 3.3010$ $n_{d9} = 1.56016$ $\nu_{d9} = 60.30$

$r_{10} = -24.8940$ (aspherical)

$d_{10} = 0.7899$

$r_{11} = -80.7304$

$d_{11} = 1.0020$ $n_{d11} = 1.80518$ $\nu_{d11} = 25.43$

$r_{12} = 21.6465$

$d_{12} = 4.0740$ $n_{d12} = 1.69680$ $\nu_{d12} = 55.53$

$r_{13} = -17.2293$

$d_{13} =$ D13 (variable)

$r_{14} = -48.1099$ (aspherical)

$d_{14} = 0.2501$ $n_{d14} = 1.52288$ $\nu_{d14} = 52.50$

$r_{15} = -65.5251$

$d_{15} = 1.3535$ $n_{d15} = 1.80610$ $\nu_{d15} = 40.95$

$r_{16} = 47.5056$

$d_{16} = 0.2911$

$r_{17} = 41.0817$

$d_{17} = 3.5899$ $n_{d17} = 1.80518$ $\nu_{d17} = 25.43$

$r_{18} = -76.4471$

$d_{18} = 3.8912$

$r_{19} = -14.7089$

$d_{19} = 1.6801$ $n_{d19} = 1.69680$ $\nu_{d19} = 55.53$

$r_{20} = -488.7372$

$d_{20} =$ D20 (variable)

$r_{21} = \infty$ (film surface)

Aspherical coefficients

Tenth surface

K $=1.5373$

$A_4 = 8.3473 \times 10^{-5}$ $A_6 = 5.1702 \times 10^{-7}$ $A_8 = -1.3021 \times 10^{-8}$

$A_{10} = 1.5962 \times 10^{-10}$

Fourteenth surface

K $=-18.4065$

$A_4 = 2.4223 \times 10^{-5}$ $A_6 = 1.3956 \times 10^{-7}$ $A_8 = -1.8237 \times 10^{-10}$

$A_{10} = 3.9911 \times 10^{-12}$

Zoom data

When an infinite object point is focused:

	Wide-angle position	Middle position	Telephoto position
D4	3.6815	10.0332	14.0700
D13	11.5705	5.2188	1.1820
D20	9.4773	31.4834	71.3185

When the object point distance is 0.6 m:

	Wide-angle position	Middle position	Telephoto position
D4	2.3504	8.3489	11.9918
D13	12.9016	6.9031	3.2602
D20	9.4773	31.4834	71.3185